///-26 /85/4 NASA Contractor Report/4610



# A Comparison of Graphite/Epoxy Tape Laminates and 2-D Braided Composites Mechanical Properties

Pierre J. Minguet and Christian K. Gunther

(NASA-CR-4610) A COMPARISON OF GRAPHITE/EPOXY TAPE LAMINATES AND 2-D BRAIDED COMPOSITES MECHANICAL PROPERTIES Final Report (Boeing Defense and Space Group) 53 p

N94-37582

Unclas

H1/26 0018514

Contract NAS1-19247 Prepared for Langley Research Center



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'ierre J. Minguet and Christian K. Gunther oeing Defense & Space Group • Philadelphia, Pennsylvania

National Aeronautics and Space Administration
Langley Research Center • Hampton, Virginia 23681-0001

Prepared for Langley Research Center under Contract NAS1-19247

#### **Abstract**

A comparison of the in-plane mechanical properties of unidirectional composite tape laminates and of 2-dimensional triaxially braided composite was conducted. The tape laminate layups were designed to match the percentage of axial fibers and the angle of the bias tows in the braided composite. The material system used for the laminates is AS4/3501-6 which was chosen as the closest available match to AS4/1895 used for the braids. This report documents the results of the testing of the laminates and compares these results with data previously obtained for the braided composite. The strength and stiffness properties measured here include tension, open-hole tension, filled-hole tension, compression and open-hole compression, all of these in both the longitudinal and transverse direction, in-plane shear and bearing.

Results show that the longitudinal modulus of both material forms is quite similar, but that the transverse modulus of the braids is lower. In terms of strength, the longitudinal unnotched strength of the braids is lower than that of the laminates, while the transverse strength is significantly lower. Similarly, the shear strength of the braids was much lower. For both strength and stiffness, the crimp in the bias tows of the braid is probably the main cause for reduced properties. On the other hand, a very significant increase in open-hole and filled-hole tension strength was observed for the braids compared to the tape laminates. However, this was not observed in compression where all the braid properties are lower than for the laminates. Bolt-bearing strength of the braids was also lower.

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#### 1. Introduction

Carbon/Epoxy composites made from textile fiber preforms manufactured with a Resin-Transfer-Molding (RTM) process have some potential for reducing costs and increasing damage tolerance of aerospace structures. One form of textile preform which is under consideration is a 2-dimensional triaxially braided fabric. A large amount of test data has been generated recently to quantify the mechanical properties of various 2-D braided configurations loaded in tension, with and without holes, compression, with and without holes, shear and bolt bearing [1].

The key question is then to determine and quantify the benefits and drawbacks of this material form. Because of the nature of the triaxial fabric (e.g., no 90° fibers), little data which could be used for a direct comparison of mechanical performance is available for more conventional material forms (i.e. tape or biaxial fabric laminates). Therefore, tape laminates with the same ply orientation and percentage of 0° fibers as the previously tested braided composites were manufactured and tested. The objectives of this report are to summarize all the strength and stiffness properties measured for the tape laminates investigated and to compare these properties with those previously determined for 2-D braided composites.

This report describes work accomplished under Contract NAS1-19247 from the National Aeronautics and Space Administration, Langley Research Center, Hampton VA. Mr Clarence C. Poe Jr., NASA LaRC, was the NASA Technical Monitor. The Structures Technology organization of the Boeing Defense & Space Group, Helicopters Division was responsible for completing this task. All specimen manufacturing and material testing was conducted at Integrated Technologies, Inc. (Intec, Bothell, WA)

## 2. Test Program Description

### 2.1 Test Matrix

Four configurations of 2-D braided composite were extensively tested in a previous investigation as reported in Reference 1. The 2-D braided fabric contains two types of tows, the longitudinal (axial, or 0°) tow and the braided (or bias) tows oriented at angle  $\theta$  of the axial tow as illustrated in Figure 2.1. The braid pattern used is 2X2 pattern, meaning that each braided tow goes over and under two tows at a time. As shown in Table 2.1, the first three architectures contain a large percentage of axial fiber typical of a composite optimized for a predominantly longitudinal loading. The first architecture, SLL, was braided with small tows to provide a fine architecture, while the third one, LLL, was braided with 2.5 times larger tows, thus allowing one to examine the influence of tow sizes. The second architecture, LLS was braided with a 45° bias angle, thus allowing one to examine the influence of braid angles. For practical applications, braid angles will often be limited to the 45° to 70° range, and the comparison of LLS and LLL allows one to examine both upper and lower bounds on that parameter. Finally, the fourth architecture, LSS, contains a larger amount of ±45° tows more typical of a composite optimized for shear loading. In addition, a fifth configuration, B1, is considered which is used in the fuselage frame for NASA/Boeing ATCAS crown panel. Only limited data were available for this material system in Reference 2. Results from this Reference were scaled up to the common 60% fiber volume fraction used in this report.

Four laminates were designed to match the bias angle and percentage of axial fibers of these braids. Two of the braids, SLL and LLL, have the same layup with different tow sizes and thus will be compared with the same laminate. The material system used is AS4/3501-6 (4.4 oz/yd<sup>2</sup>) which closely matches the AS4/1895 system used for the braids. The following four laminates were used:

Laminate 1:  $[(45/0/-45/0)_2/45/0/-45]_s$ 

22 Plies Total, 10 0° Plies (45.4%), 12 45° Plies, to match LLS.

**Laminate 2:**  $[(70/0/-70/0)_2/70/0/-70]_s$ 

22 Plies Total, 10 0° Plies (45.4%), 12 7 )° Plies, to match SLL and LLL.

Laminate 3:  $[(\pm 45)_2/0/(\pm 45)_3/0(\pm 45)_3/0/(\pm 45)_2]_t$ 

23 Plies Total, 30° Plies (13.0%), 20 45° Plies, to match LSS.

**Laminate 4:**  $[(66/0/-66)_4/0]_s$ 

26 Plies Total, 10 0° Plies (38.5%), 16 66° Plies, to match B1.

Table 2.1 Description of 2-D braid architectures.

Name	Longitudinal Tow Size	Braided Tow Size	% Longitudinal Tow	Braid Angle [°]	Unit Cell Width [in]	Unit Cell Length [in]
SLL	30 K	6 K	46	70	0.458	0.083
LLS	36 K	15 K	46	45	0.415	0.207
LLL	75 K	15 K	46	<b>7</b> 0	0.829	0.151
LSS	6 K	15 K	12	45	0.415	0.207
B1	18 K	6 K	37	66	0.105	0.046

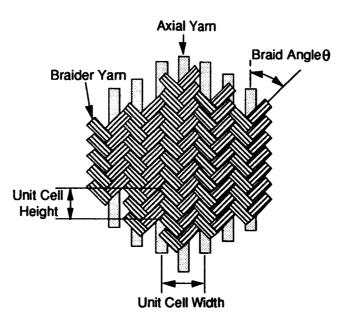


Figure 2.1 Illustration of 2-D Triaxial Braid Configuration.

#### 2.2 Test Matrix

The complete test matrix for this program is shown in Table 2.2. A total of 180 specimens were used. All the in-plane material properties considered in Ref. 1 were considered here. Standard size specimen, 12" long and 1.5" wide, were used for the tension tests. Modified IITRI specimens, 1.5" long by 1.5" wide test section, were used for the compression tests. The laminate thickness was doubled for the compression specimen to insure specimen stability. A hole diameter of 0.188" was mistakenly used in the compression test instead of the standard 0.250".

Table 2.2 Tape Laminates Test Program

		Lamina	te Type	
Test Type	1	2	3	4
Tension				
Longitudinal	3	3	3	3
Transverse	3	3	3	3
Open-Hole Tension				
Longitudinal ( $D = 0.188'', 0.250''$ )	6	6	6	6
Transverse ( $D = 0.188'', 0.250''$ )	6	6	6	6
Compression				
Longitudinal	3	3	3	3
Transverse	3	3	3	3
Open-Hole Compression				
Longitudinal (D=0.188")	3	3	3	3
Transverse ( $D = 0.188''$ )	3	3	3	3
In-Plane Shear				
Boeing Rail Shear	3	3	3	3
Bolt Bearing & Bypass				
Filled-Hole Longitudinal Tension	3	3	3	3
Filled-Hole Transverse Tension	3	3	3	3
Single Shear Bearing	3	3	3	3
Double Shear Bearing	3	3	3	3
TOTALS	45	45	45	45

## 2.3 Data Reduction Techniques

The same approach used in Reference 1 was used here to make all results directly comparable. All results are normalized to a 60% fiber volume fraction. Fiber volume fraction and thickness were measured on all manufactured panels. After averaging these data over all panels, a nominal ply thickness of 0.0054" was calculated. All stiffness moduli and Poisson's coefficients are the initial value of these properties and were measured with a linear regression between 0.001 and 0.003 strain levels. Wherever a nominal strain is reported, it is equal to the strength divided by the initial modulus. Actual strain is the last reading obtained from a strain gage prior to failure. Strength is always calculated as load divided by actual width and nominal thickness.

Open-hole and filled-hole strength results were corrected to infinite plate width with the following formula for a hole diameter d and a plate width w:

$$\sigma_{\infty} = \left[ \frac{2 + \left(1 - \frac{d}{w}\right)^3}{3\left(1 - \frac{d}{w}\right)} \right] \cdot \frac{P}{w \ t_{nom}}$$

## 3. Tension Properties

Tension properties for all four laminates were measured in both the longitudinal (0°) and transverse (90°) directions. Properties included stiffness modulus, Poisson's coefficient, open-hole strength (01.88" and 0.250" diameters) and filled-hole strength using a fully-torqued 0.25" titanium hilock fastener.

#### 3.1 Laminate Results

All the tension properties measured in the longitudinal (0°) direction are shown in Table 3.1, while all the properties measured in the transverse (90°) direction are shown in Table 3.2. Individual test results and typical stress-strain curves can be found in Appendix A and B respectively.

**Table 3.1 Laminate Longitudinal Tension Properties** 

Property	Laminate 1	Laminate 2	Laminate 3	Laminate 4
Modulus [msi]	10.33	9.63	4.92	8.23
CoV [%]	0.8	2.8	0.5	2.0
Poisson's Coefficient	0.663	0.157	0.713	0.190
CoV [%]	2.3	3.7	0.8	0.1
Unnotched Strength [ksi]	131	132	63	105
Nominal Strain [μs]	12,690	13,750	12,840	12,720
CoV [%]	12.5	6.3	1.8	5.3
Actual Strain [μs]	12,300	13,400	15,200	12,800
0.188" OHT Strength [ksi]	72	66	42	61
OHT Nom. Strain [µs]	6,960	6,860	8,460	7,450
CoV [%]	4.4	1.0	2.0	3.7
0.250" OHT Strength [ksi]	69	66	40	60
OHT Nom. Strain [µs]	6,640	6,820	8,080	7,340
CoV [%]	3.8	3.6	1.2	1.7
0.250" FHT Strength [ksi]	60	49	42	47
FHT Strain [µs]	5,820	5,090	8,560	5,710
CoV [%]	2.1	1.8	2.7	3.6

Note: Laminate 1 [(45/0/-45/0)2/45/0/-45]<sub>s</sub>

Laminate 2 [(70/0/-70/0)2/70/0/-70]<sub>S</sub>

Laminate 3  $[(\pm 45)2/0/(\pm 45)3/0/(\pm 45)3/0/(\pm 45)2]_t$ 

Laminate 4  $[(66/0/-66)4/0]_s$ 

Coefficients of variation were generally quite low and well within the typical values obtained when testing composites. The only exception was the unnotched  $0^{\circ}$  strength of L1 for which one specimen failed prematurely. If that data point was excluded, L1 strength would be 141 ksi (13,600  $\mu$ s). Laminate 1, 2 and 4 were linear to failure, as

indicated by the fact that actual and nominal strains are virtually equal, while laminate 3 (with a high percentage of ±45° plies) had a softening behavior with the actual strain much higher than nominal. Failure for L1 and L2 occured close to the tabs, and for L4 occured under the tabs. L3 exhibited a large amount of delamination.

Somewhat different failure modes were observed in the 90° unnotched tension tests. Laminates 1 and 2 exhibited a clean straigth break well inside the test section. Laminate 3 also failed inside the test section and showed mostly an in-plane shear failure mode, along with some visible edge delaminations. Laminate 4 exhibited a large amount of delamination initiating from the edges. Laminate 1 and 3 had a softening behavior because of their 45° ply angle. The strain levels in L2 and L4 were much below that in the 0° tests, indicating that pure fiber fracture was not the dominant failure mode.

All laminates but L3 show a strong sensitivity to the presence of a fully torque fastener in the longitudinal tension test. Strength reductions were 13% for L1, 26% for L2, 22% for L4. In the transverse direction, the influence of the fastener was quite different. A strength increase was observed for L1 (+18%) and L2 (+3%), while a strength decrease was observed for L2 (-10%) and L4 (-7%). Note that the strength increase was observed for the two laminates with a low transverse modulus.

Table 3.2 Laminate Transverse Tension Properties

Property	Laminate 1	Laminate 2	Laminate 3	Laminate 4
Modulus [msi]	3.37	8.96	3.48	8.88
CoV [%]	0.9	0.6	1.5	1.9
Poisson's Coefficient	0.225	0.147	0.513	0.223
CoV [%]	9.4	3.9	1.1	2.6
Unnotched Strength [ksi]	35	72	35	73
Nominal Strain [µs]	10,480	8,020	10,030	8,180
CoV [%]	1.8	3.3	0.9	4.6
Actual Strain [µs]	15,600	8,300	14,800	8,600
0.188" OHT Strength [ksi]	31	59	33	58
OHT Nom. Strain [µs]	9,210	6,580	9,520	6,550
CoV [%]	1.2	3.5	0.6	3.6
0.250" OHT Strength [ksi]	28	53	32	54
OHT Nom. Strain [µs]	8,359	5,910	9,140	6,110
CoV [%]	2.7	3.4	0.8	0.5
0.250" FHT Strength [ksi]	33	50	33	52
FHT Strain [μs]	9,660	5,580	9,430	5,810
CoV [%]	2.3	3.1	0.5	3.1

Note: Laminate 1 [(45/0/-45/0)2/45/0/-45]<sub>S</sub>

Laminate 2 [(70/0/-70/0)2/70/0/-70]s

Laminate 3  $[(\pm 45)_2/0/(\pm 45)_3/0/(\pm 45)_3/0/(\pm 45)_2]_t$ 

Laminate 4  $[(66/0/-66)4/0]_s$ 

#### 3.2 Comparison with Braided Composite

The first comparison, shown in Figure 3.1, is for longitudinal modulus. Minimal differences were found between braids and tape laminates: +0.4% for SLL, -4.6% for LLL, -0.9% for LLS, and -0.6% for LSS. Considering experimental scatter and the slight differences in percentage of 0°, it is fair to say that there is no difference between longitudinal moduli for the two material forms. The slight reduction for LLL is probably due to the additional tow waviness introduced by the use of large tow sizes.

The comparison is quite different for the transverse modulus. As shown in Figure 3.1, the braided material is substantially less stiff: -19% for SLL, -24% for LLL, -22% for LLS, and -16% for LSS. The primary cause for this reduction is the crimp in the bias tows.

The comparison for unnotched longitudinal tension strength is show in Figure 3.2.a to 3.2.d. A notably lower strength was obtained for all the braids: -17% for SLL, -34% for LLL, -31% for LLS, and -16% for LSS. Once again, the tow waviness is a probable contributor to this loss of strength. However, it is somewhat surprising that there was so little difference in modulus and such difference in strength. Another possible contributor is the matrix material. Although 1895 and 3501-6 are rather similar epoxys, it is possible that 1895 is more brittle or has a lower strain to failure than 3501-6.

The open-hole tension strength comparison is based on the standard 1/4" diameter hole which is often used in developing material allowables. In Reference 1, several hole diameters were tested for each braided material. A log-log best fir curve of strength versus hole diameter was then calculated. This procedure showed that the data at some of the hole diameters did not follow the overall trend due to experimental scatter. This was the case for the 1/4" hole in the SLL and LLS architecture. Thus, instead of using the data for the 1/4" hole, the strength is calculated with the following best fit equations:

SLL: 
$$\sigma = 72.2 * d^{-.165}$$
 LLL:  $\sigma = 53.0 * d^{-.315}$  LLS:  $\sigma = 61.3 * d^{-.208}$  LLS:  $\sigma = 28.8 * d^{-.265}$ 

Results in Figure 3.2 show a clear strength advantage for the braided materials. The relative differences between braid and laminate strength were +37% for SLL, +24% for LLL, +20% for LLS, and +4% for LSS. Since moduli are quite similar for each braid and equivalent laminate, the differences in term of nominal strain are about the same.

This strength difference is further magnified in the filled-hole tension test. As mentioned above, the laminated material was quite sensitive to the presence of a fastener, while the data in Ref. 1 showed that the braids were not. The relative differences in term of strength were: +72% for SLL, +47% for LLL, and +19% for LLS (no data is available for LSS).

Post-failure examination of the braided specimens revealed extensive matrix failure between the axial and bias tows which would tend to reduce the stress concentration for axial yarns. On the other hand, examination of the laminated specimen showed a fairly clean fracture surface across the specimen net section. Thus, 2D braids may have advantages over tape laminates with regard to open- and filled-hole tension strengths.

Strength measured along the transverse direction for these materials is shown in Figure 3.3.a to 3.3.d. For the unnotched case, the braided material show a severe strength reduction compared to the tape laminates: -51% for SLL, -57% for LLL, -57% for LLS, and -29% for LSS. Once again, the crimp in the bias tows is the likely cause for the strength reduction.

Only a limited set of data is available for the transverse open-hole tension strength of the braided material. A single hole size of 1/4" was tested and is used for comparison. Somewhat surprisingly, these materials exhibited no notch sensitivity, and in some cases, the strength was slightly higher than that for the unnotched case. The data is probably too limited at this point to draw any definite conclusion. The tape laminates did show some notch sensitivity, and thus the differences in strength between the two material forms are reduced compared to the unnotched case: -36% for SLL, -43% for LLL, -46% for LLS, and -16% for LSS.

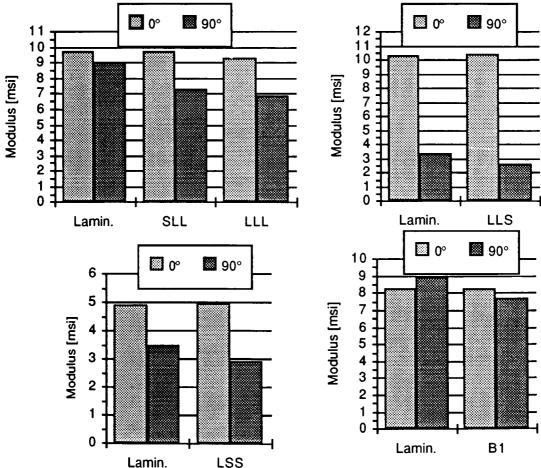


Figure 3.1 Comparison of Longitudinal and Transverse Tension Modulus.

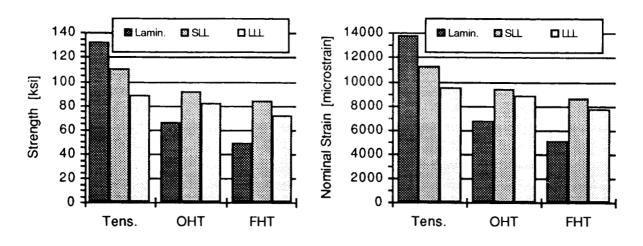


Figure 3.2.a Comparison of 0° Tension Strength for Tape Laminate 1, SLL and LLL.

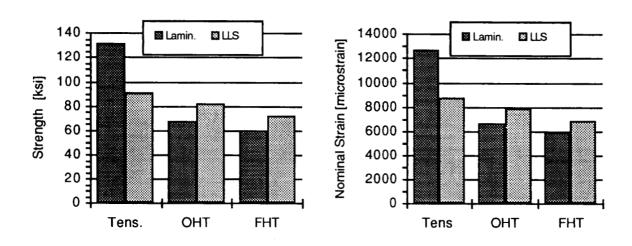


Figure 3.2.b Comparison of 0° Tension Strength for Tape Laminate 2 and LLS.

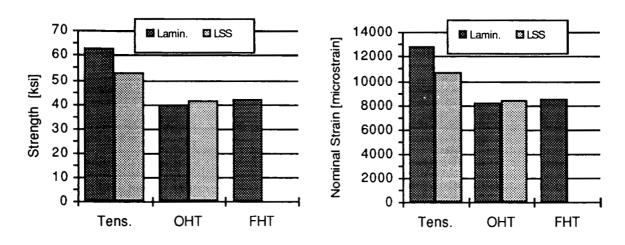


Figure 3.2.c Comparison of 0° Tension Strength for Tape Laminate 3 and LSS.

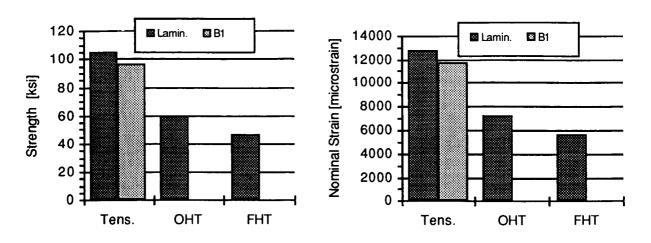


Figure 3.2.d Comparison of 0° Tension Strength for Tape Laminate 4 and B1.

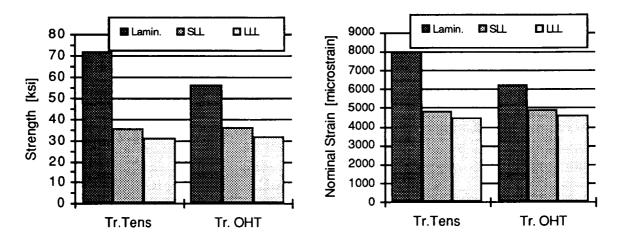


Figure 3.3.a Comparison of 90° Tension Strength for Tape Laminate 1, SLL and LLL.

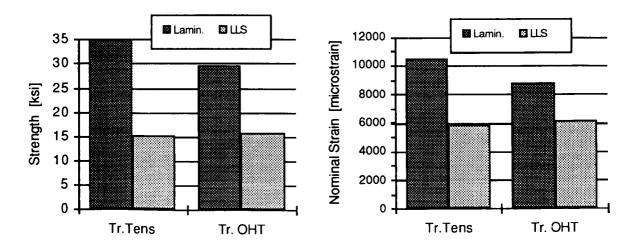


Figure 3.3.b Comparison of 90° Tension Strength for Tape Laminate 2 and LLS.

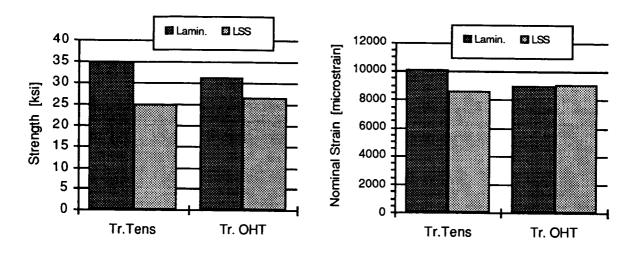


Figure 3.3.c Comparison of 90° Tension Strength for Tape Laminate 3 and LSS.

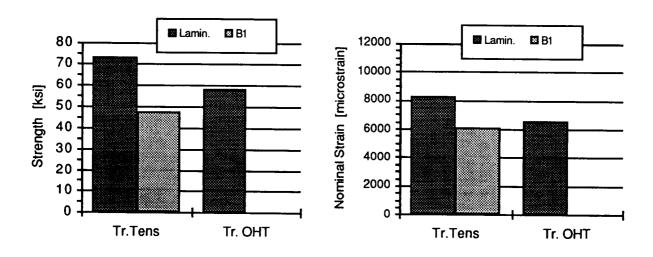


Figure 3.3.d Comparison of 90° Tension Strength for Tape Laminate 4 and B1.

## 4. Compression Properties

Compression properties for all four laminates were also measured in both the longitudinal (0°) and transverse (90°) directions. Properties included stiffness modulus, Poisson's coefficient and open-hole strength (0.188" diameter). A modified IITRI test specimen [1] with a test section of 1.5" by 1.5" was used for all tests.

## 4.1 Laminate Results

All the compression properties measured in the longitudinal (0°) direction are shown in Table 4.1, while all the properties measured in the transverse (90°) direction are shown in Table 4.2. Individual test results and typical stress-strain curves can be found in Appendix A and B respectively. Coefficients of variation were generally quite low and well within the typical values obtained when testing composites. Some of the exceptions were the unnotched 0° strength of L1, notched 90° strength of L1 and unotched 90° strength of L2. The nominal strains reported in this section were always calculated with the compression modulus. When comparing the compression moduli to the ones measured in tension, significant differences were observed, 17% lower for L1, 13% for L2, 16% for L3 and 14% L4. A similar observation can me made for the transverse modulus: 8% lower for L1, 14% for L2, 13% for L3 and 18% for L4. Although it is typical for composites to be softer in compression, these differences are slightly higher than expected. The test specimen itself, with a short and wide test section, is believed to be partly responsible for this effect. Longitudinal fiber strains at failure were fairly typical of this type of material, ranging from 0.95% to 1.1%. High strains to failure were measured wherever there was a large percentage of ±45° fibers, such as in the 0° and 90° test of L3 and in the 90° test of L1.

**Table 4.1 Laminate Longitudinal Compression Properties** 

Property	Laminate 1	Laminate 2	Laminate 3	Laminate 4
Modulus [msi]	8.84	8.53	4.25	7.22
CoV [%]	1.0	2.1	1.6	1.5
Poisson's Coefficient	0.704	0.172	0.712	0.227
CoV [%]	3.0	1.8	3.2	2.9
Unnotched Strength [ksi]	84	82	58	<b>7</b> 9
Nominal Strain [µs]	9,500	9,640	13,560	10,880
CoV [%]	9.9	5.5	5.1	1.1
0.188" OHT Strength [ksi]	65	<b>7</b> 5	43	69
OHT Nom. Strain [µs]	7,330	8 <i>,</i> 770	10,210	9,550
CoV [%]	1.5	2.0	1.4	1.9

Note: Laminate 1 [(45/0/-45/0)2/45/0/-45]s

Laminate 2 [(70/0/-70/0)<sub>2</sub>/70/0/-70]<sub>s</sub>

Laminate 3  $[(\pm 45)_2/0/(\pm 45)_3/0/(\pm 45)_2]_t$ 

Laminate 4  $[(66/0/-66)4/0]_s$ 

**Table 4.2 Laminate Transverse Compression Properties** 

Property	Laminate 1	Laminate 2	Laminate 3	Laminate 4
Modulus [msi]	3.13	7.84	3.08	7.52
CoV [%]	0.6	1.3	1.5	1.9
Poisson's Coefficient	0.237	0.151	0.525	0.226
CoV [%]	2.1	6.7	2.5	4.0
Unnotched Strength [ksi]	50	70	48	74
Nominal Strain [µs]	15,880	8,930	15,720	9,780
CoV [%]	4.9	12.3	1.5	1.4
0.188" OHT Strength [ksi]	42	61	44	59
OHT Nom. Strain [µs]	13,520	7,830	14,220	7,850
CoV [%]	7.6	1.3	0.4	2.6

Note: Laminate 1 [(45/0/-45/0)2/45/0/-45]<sub>s</sub>

Laminate 2 [(70/0/-70/0)2/70/0/-70]<sub>s</sub>

Laminate 3  $[(\pm 45)2/0/(\pm 45)3/0/(\pm 45)3/0/(\pm 45)2]_t$ 

Laminate 4  $[(66/0/-66)4/0]_S$ 

#### 4.2 Comparison with Braided Composite

The first comparison, shown in Figure 4.1, is for modulus. Small differences were found between braids and tape laminates for the longitudinal modulus, +4.6% for SLL, -1.9% for LLL, -0.2% for LLS, and 3.1% for LSS, and for the transverse modulus, +7.5% for SLL, -5.4% for LLL, -3.2% for LLS, and -1.6% for LSS. The differences for the transverse modulus are less than those observed in the tension case. Based on these observations, it would appear that the modulus measured in the laminated specimen might be somewhat under-estimated, although no precise cause was found for this effect.

The comparison for unnotched longitudinal compression strength is shown in Figure 4.2.a to 4.2.d. As anticipated, a lower strength was obtained for all the braids: -14% for SLL, -28% for LLL, -31% for LLS, and -16% for LSS. Once again, the tow waviness is a probable contributor to this loss of strength.

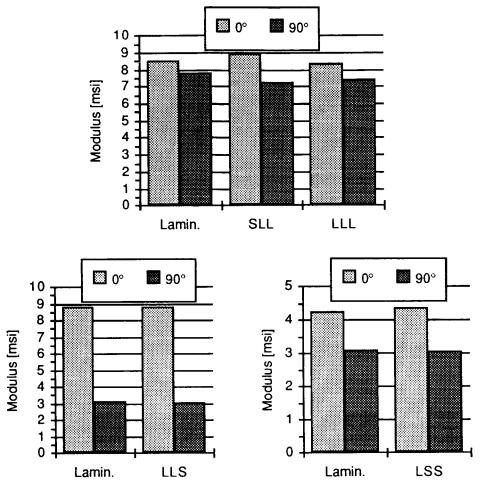


Figure 4.1 Comparison of Longitudinal and Transverse Compression Modulus.

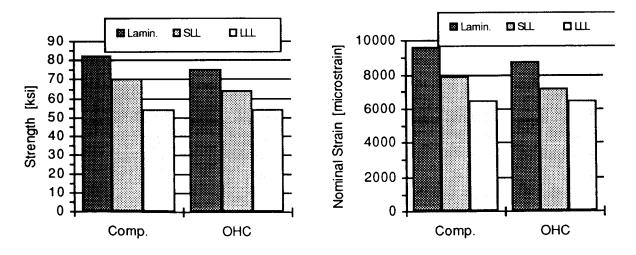


Figure 4.2.a Comparison of 0° Compression Strength for Tape Laminate 1, SLL and LLL.

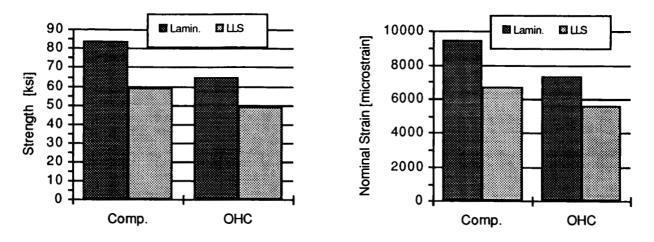


Figure 4.2.b Comparison of 0° Compression Strength for Tape Laminate 2, LLS.

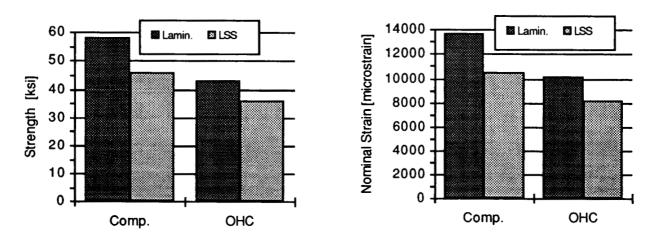


Figure 4.2.c Comparison of 0° Compression Strength for Tape Laminate 3, LSS.

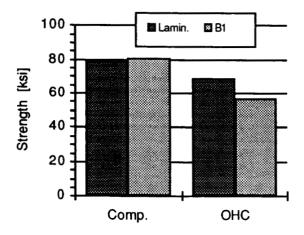


Figure 4.2.d Comparison of 0° Compression Strength for Tape Laminate 4, B1.

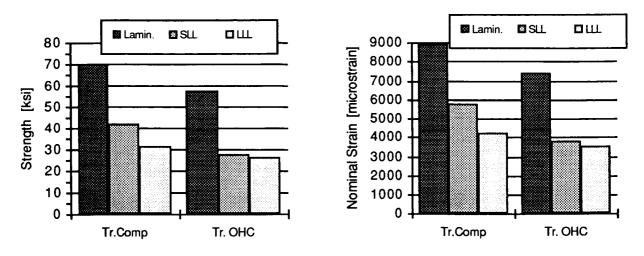


Figure 4.3.a Comparison of 90° Compression Strength for Tape Laminate 1, SLL and LLL.

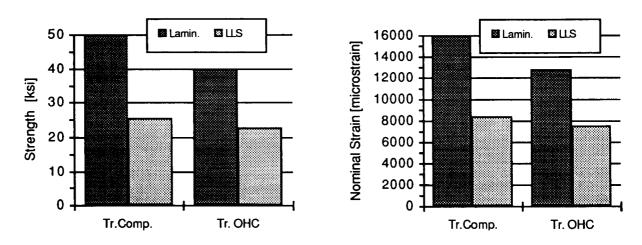


Figure 4.3.b Comparison of 90° Compression Strength for Tape Laminate 2, LLS.

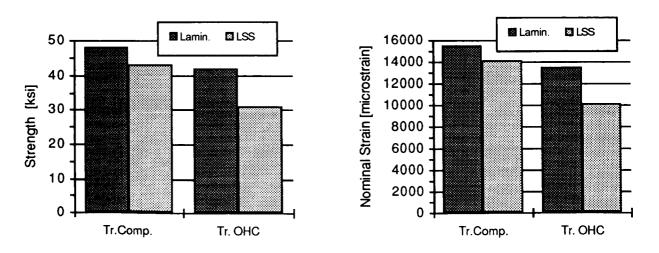


Figure 4.3.c Comparison of 90° Compression Strength for Tape Laminate 3, LSS.

## 5. Shear Properties

In-plane strength was measured for all four laminates using the rail shear test method. All specimens were tabbed with 0.125" thick quasi-isotropic graphite/epoxy tabs to avoid the bearing failures encountered in Reference 1.

#### 5.1 Laminate Results

Stiffness and strength results are shown in Table 5.1. Individual test results can be found in Appendix A. Unfortunately, bearing failures were experienced in all the laminates except L2. Thus, the reported strength is actually a lower bound to the actual shear strength of these laminates.

Table 5.1 Laminate Shear Properties

Property	Laminate 1	Laminate 2	Laminate 3	Laminate 4
Modulus [msi]	2.74	1.68	4.05	2.13
CoV [%]	3.2	6.5	2.9	2.7
Shear Strength [ksi]	35	36	36	32
CoV [%]	7.1	4.7	4.1	4.8

Note:

Laminate 1 [(45/0/-45/0)2/45/0/-45]s

Laminate 2 [(70/0/-70/0)2/70/0/-70]s

Laminate 3  $[(\pm 45)2/0/(\pm 45)3/0/(\pm 45)3/0/(\pm 45)2]t$ 

Laminate 4 [(66/0/-66)4/0]s

### 5.2 Comparison with Braided Composite

The comparison of shear moduli is shown in Figure 5.1, and of the shear strength in Figure 5.2. For the 2-D braids, the results of the rail shear testing in Reference 1 were used in the comparison. Results show that the measured moduli are fairly comparable, but that there is a significant difference in strength. That difference is consistant with the low transverse strength observed in the transverse tension and transverse compression tests. Because of the bearing failures encountered in the tape laminate tests and the LSS tests, it is not possible to put an exact figure on the difference between the two material forms. Based on the results for Laminate 2 (which failed in shear), SLL and LLL, the shear strength reduction could be as high as 50%. However, that layup is not well suited to carry shear loads. Laminate 3 and LSS were optimized for shear. Data show that the fiber strain level was about -8,000 microstrain in L3 when bearing failure occured. If one assumes a compression failure in the 45° plies as the failure mode if no premature bearing failure had occured, results in Section 4 show that at least -9,500 microstrain can be achieved along the fiber direction (see L1 in Table 4.1). This would translate to a minimum shear strength of 43 ksi for L3, or about 33% more than LSS.

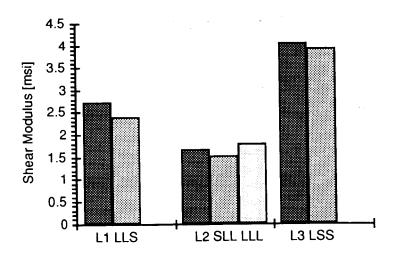


Figure 5.1 Comparison of In-Plane Shear Modulus of Laminates and 2-D Braids.

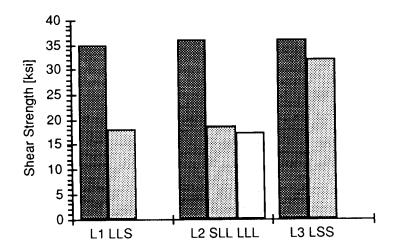


Figure 5.2 Comparison of In-Plane Shear Strength of Laminates and 2-D Braids.

## 6. Bolt Bearing Properties

Bolt bearing strength was measured for all four laminates using two test configurations, the stabilized single shear specimen and the double shear specimen [1]. A fully torqued 1/4" titanium HiLock fastener was installed in both cases, and the standard values of W/D of 6 and e/D of 3 were used for both configurations.

### 6.1 Laminate Results

Bolt bearing strength was measured for all four laminates using two test configurations, the stabilized single shear specimen and the double shear specimen. Ultimate bearing strength results are reported in Table 6.1. Individual test results can be found in Appendix A. Interestingly, the strength is almost identical for all four layups in both types of test. As expected, the double shear test always produced higher bearing strength by about 20 to 30%.

Table 6.1 Laminate Bearing Strength Properties

Property	Laminate 1	Laminate 2	Laminate 3	Laminate 4
Single Shear Strength [ksi]	119	122	118	119
CoV [%]	4.1	1.3	2.0	2.5
Double Shear Strength [ksi]	143	154	144	158
CoV [%]	3.9	1.9	5.0	4.5

Note: Laminate 1 [(45/0/-45/0)2/45/0/-45]s

Laminate 2 [(70/0/-70/0)2/70/0/-70]s

Laminate 3  $[(\pm 45)2/0/(\pm 45)3/0/(\pm 45)3/0/(\pm 45)2]t$ 

Laminate 4 [(66/0/-66)4/0]s

#### 6.2 Comparison with Braided Composite

The comparison with the braided material is shown in Figure 6.1, but data from Reference 1 or 2 was not available for both test methods and all braids. Lower strength were obtained with the braids in all cases where data was available. In single shear, reductions were -16% for SLL, -25% for LLL and -30% for LLS, while in double shear, the reductions were -12% for SLL and -13% for LLS.

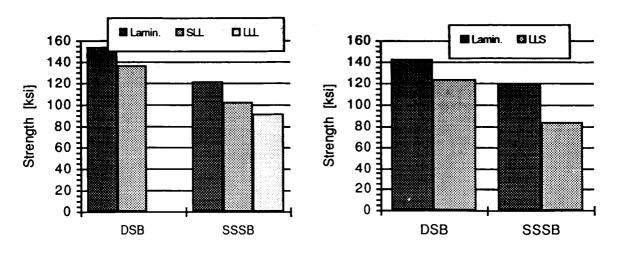


Figure 6.1 Comparison of Bearing Strength for Tape Laminate 1, 2 and braids SLL, LLL and LLS.

## References

- 1. Minguet, P.J., Fedro, M.J., Gunther, C.K., "Test Methods for Textile Composites", NASA CR-4609, 1994.
- 2 Masters, J.E., Foye, R.L., Pastore, C.M., Gowayed, Y.A., "Mechanical Properties of Triaxially Braided Composites: Experimental and Analytical Results," Proceedings of the Ninth DoD/NASA/FAA Conference on Fibrous Composites in Structural Design, Lake Tahoe, Nevada, November 1991.

# Appendix A Test Data

## Appendix A Test Data

All the individual test data are included in this appendix as reported by Intec. Note that stresses in these spreadsheets are normalized by the actual specimen thickness.

Intec Project #: BH0003	H0003						გ	mpariso	n of Lam fo	inated C r Boeing	minated Composites to for Boeing Helicopters	Comparison of Laminated Composites to Braided Textiles for Boeing Helicopters	ed Textile	<b>8</b>		
Temperature: intec engineer: Boeing engineer:		RT Maryan Pierre I	RT Maryann Einarson Pierre Minguet	COS					Tena	Tension Results	ılts					
Specimon	Toet	Mat	Panel	Fiber	Fiber Lave Dimensions (in) Load	rions (in)	Load at	5	3	Ultimate	Ultimate	Ultimate	Exten.	Ax. SG	Poisson's	Failure Mode/
	_	- 40		<u>8</u>	Width	Thick	Audible	Load	Stress	Ext. Strn	Ę	Trans. Stm	Modulus	Modulus	Patio	Comments
				શ		ness	(kips)	(kips)	(ksi)	(mg)	370	3900	14 024	11 284	0 660	Failed in cace section
BH3-001	Tens	-	_	66.3	1.499	0.1083	17.00	25.674	158.168		13,536	000	1.004	11.450	0890	Failed in gage section
BH3-005	Tens	-	4	66.3	1.500	0.1083	14.20	24.385	150.142		12,714	7.03	11.07	11 167	0.650	Failed in gage section
ВН3-003	Tens	-	┪	66.3	- 8	0.108/	3	20.116	122.130			, 200	11 63	11 30	0.663	
						Average	16.37	23.39	143.50		882,21	70,5	7	2 4	2000	
						Std. Dev		2.91	18.88		1489	1316			0.00	
						\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \		12.44	13.16		12.10	-14.61	3.84	3	6.303	
010	200	,	8	65.7	1501	0 1071	7.40	22.203	138.162		12,867	-1,805	10.447	10.346	0.150	Failed at upper tab edge
610-5110	2 2	10		65.7	200	0.1075	8.00	23.492	145.705		13,267	-1,877	10.631	10.828	0.160	Failed in gage section
020-50-0	2 6	, ,	- K	65.7	5	0 1089	8.70	25.180	154.118		14,161	-1,980	10.480	10.687	0.160	Failed in gage sec., severe delan
BH3-021	2	1	5	3	1	Average	8 03	23.63	146.00		13,432	-1,887	10.52	10.62	0.157	
						Std Dev		1.49	7.98		663	88	0.10	0.25	9000	
						200		6.32	5.47		4.93	-4.66	0.93	2.33	3.685	
		,	1	0 30	1 500	0 1117	10 40	11 992	71.580	16196	15,845	ęu	5.447	5.455	0.710	Failed in gage section
BH3-037	Sup	n (	ξ <del>ξ</del>	0.00	3 5	0 1145		11.618	67.660	15202	15,101	E.	5.368	5.310	0.710	Failed in gage section
BH3-038	STB -	? ·	5 6	2.00	3 5	0 1145	07 6	11.653	67.829		14,780	Ē	5.321	5.362	0.720	Failed in gage section
BH3-038	SUB	?	5	3	3	Average	1_	11.75	69.02	15699	15,242		5.38	2.38	0.713	
						Std Dev		0.21	2.22		546		90.0	0.07	90.0	
						3 6		1.76	321		3.58		1.18	1.37	0.809	
3.0	i	ŀ	Ş	6 13	5	0 1261	15.80	20.903	110.493		12,574	-2,243	9.214	8.953	0.190	Failed at lower tab edge beginning
BH3-022	2 1		<b>•</b> •	2 2		0 1295	12.40	21.805	112.314		12,552	-2,274	9.003	080.6	0.190	Failed at lower tab eoge beginning
BH3-026	SIE	•	<b>;</b>	5 2		0 1299	12.00	23.213	119.222		13,375	-2,424	8.852	883	0.190	Failed at lower tab edge beginner
BH3-05/	2	•	ş	?	L	Average	1.	21.97	114.01		12,834	-2,314	9.05	8.97	0.190	
						Std Dev		1.16	4.61		469	97	0.18	0.1		-
						20%		5.30	4.04		3.65	-4.18	2.05	1.22		

Intec Project #: BH0003	BH0003	<b></b>					ၓ	mparisc	n of Lan fo	าinated C งr Boeing	minated Composites to for Boeing Helicopters	Comparison of Laminated Composites to Braided Textiles for Boeing Helicopters	ed Textil	S) B)		
Temperature:	.e.:	RT	RT Marvann Einarson	COS.						•	•					
Boeing engineer:	ineer:	Pierre	Pierre Minguet	_				-	ransvers	e Tensio	Transverse Tension Results	62				
Specimen	Test	Mat.	Panel	Fiber J	Panel   Fiber   Ave Dimensions (in)	rsions (in)	Load at	) O	Ji.	Ultimate	Ultimate	Ultimate	Exten.	Ax. SG	Poisson's	Failure Mode/
9	Type			<u> </u>	Width	Thick	-	Load	Stress	Ext. Strn	Axial Stm	Ē	Modulus	Modulus	Ratio	Comments
				3		ness	(Kips)	(sdix)	(ksi)	(36)	(311)	(311)	(Mpsi)	(Mpsi)		
BH3-076	Þ	-	<u>—</u>	6.99	1.502	0.1075	i	6.440	39.864	15614	•		3.790			No axial strn data
BH3-077	F	-	<b>6</b>	6.99	1.50	0.1085	8.3	6.278	38.545	15773	15,710	-3,870	3.631	3.723	0.240	Failed in gage section and at grip
BH3-078	F	-	18	6.99	1.50	0.1087	4.60	6.222	38.129		15,560	-3,362	3.553	3.669	0.210	Failed in gage section
						Average	4.45	6.31	38.85	15694	15,635	-3,616	3.66	3.7	0.225	
						Std. Dev		0.11	0.91	112	\$	359	0.12	9.0	0.021	
						% COV		1.79	2.33	0.72	0.68	-9.93	3.30	1.03	9.428	
BH3-088	F	2	28	0.99	1.502	0.1072	11.00	12.370	76.861		8,019	-1,120	9.549	9.885	0.150	Failed in gage section
BH3-089	F	8	<b>5</b> B	0.99	1.502	0.1063	11.90	12.987	81.334	9524	8,380	-1,156	9.821	10.090	0.150	Failed in gage section
BH3-090	Þ	2	<b>5B</b>	0.99	1.502	0.1077	12.10	13.170	81.405		8,597	-926	9.526	9.896	0.140	Failed in gage section
						Average	11.67	12.84	79.87	9524	8,332	-1,067	9.63	96.6	0.147	
						Std. Dev		0.42	2.60		292	124	0.16	0.12	9000	
						% OV		3.26	3.26		3.50	-11.59	1.70	1.16	3.936	
BH3-100	F	3	38	66.2	1.502	0.1127	6.40	6.556	38.729	14473	15,739	026'8-	3.878	3.809	0.510	Failed in gage section
BH3-101	F	က	8	66.2	1.502	0.1125	6.40	6.500	38.465	13024	14,339	-8,659	4.061	3.900	0.520	Failed in gage section
BH3-102	F	9	38	66.2	1.501	0.1133	6.20	6.439	37.859	13720	14,267	-8,318	3.965	3.760	0.510	Failed in gage section
					-	Average	6.33	6.50	38.35	13739	14,782	-8,649	3.97	3.82	0.513	
						Std. Dev		90.0	0.45	725	830	326	60.0	0.07	9000	
						% COV		0.00	1.16	5.27	5.61	-3.77	2.31	1.86	1.125	
BH3-112	F	4	T	66.4	1.503	0.1304	14.90	15.536	79.269		069'8	-2,009	9.508	9.543	0.220	Failed in gage section
BH3-113	F	4	8	66.4	1.503	0.1292	14.50	15.852	81.629		9,039	-1,662	9.419	9.808	0.220	Failed in gage section
BH3-114	F	4	48	66.4	1.503	0.1296	13.90	14.497	74.451		8,171	-1,838	9.572	9.413	0.230	Failed at upper grip edge
						Average	14.43	15.29	78.45		8,633	-1,836	9.50	9.59	0.223	
						Std. Dev		0.71	3.66		437	174	0.08	0.20	9000	
						% COV		4.63	4.66		5.06	-9.45	0.81	2.10	2.585	

e: ineer: Test Type					for Boeing Helicopters		for Boeing Helicopters	ing Helic	opters	4.5			
ts es	ВТ							)					
Test Type	Maryann Einarson Pierre Minguet	ın Eina Mingue	rson				Open Hol	Open Hole Tension Results	Results				
Туре		100	locod	104	Average	Average Dimensions (inches)	vi) addia	hoel		l pag at	timate	1 Utimate	Failure Location/
adk -	Zal.	_	<u>g</u> C	HOLL V	Wight	ly one h	Thick	Hole	C/ X	Audible	0 20	Stress	Comments
1	Sass	*		# (%)		T A L	ness	Dia 1	) È	(kips)	(kips)	(ksi)	
	Mat.	3	Panel	Fiber	Avera	Average Dimensions (inches)	ni) snoist	ches)		Load at	Ultimate	Ultimate	Failure Location/
Туре	Class	*		Volume	Width	Length	Thick-	Hole	Q/M	Audible	Load	Stress	Comments
				(%)			ness	Dia 1		(kips)	(kips)	(ksi)	
BH3-004 OHT	-	က	14	66.3	1.502	11.5	0.1137	0.1880	80		12.65	74.09	Hole/delamination
	-	ო	14	66.3	1.502	11.5	0.1117	0.1880	æ		12.07	71.98	Hole/delamination
	-	ო	4	66.3	1.502	11.5	0.1137	0.1885	8		13.20	77.27	Hole/delamination
L								Average			12.64	74.45	
								Std. Dev.			0.56	5.66	
								% COV			4.44	3.57	
ВНЗ-022 ОНТ	2	16	2A	65.7	1.502	12.0	0.1084	0.1885	8	9.35	11.51	70.74	Failed at Hole
	Q	9	2A	65.7	1.502		0.1087	0.1885	80	9.20	11.58	70.93	Failed at Hole
	8	16	2A	65.7	1.503	12.0	0.1079	0.1885	8	9.25	11.75	72.43	Failed at Hole
丄								Average		9.27	11.61	71.36	
								Std. Dev.	•		0.12	0.93	
							,	% COV			1.03	1.30	
BH3-040 OHT	6	29	3.4	65.8	1.501	11.5	0.1142	0.1890	8	7.05	7.80	45.50	Failed at Hole
	ო	29	3A	65.8	1.502	11.5	0.1135	0.1895	80	6.80	7.58	44.45	Failed at Hole
	ო	53	3 A	65.8	1.503	11.5	0.1125	0.1185	8	7.05	7.60	44.92	Failed at Hole
<u>L</u>								Average		6.97	7.66	44.96	
					-		<u>~~</u>	Std. Dev.			0.12	0.52	
						,		% COV			1.60	1.16	
BH3-058 OHT	4	42	44	64.3	1.503		0.1293	0.1895	8	8.95	13.07	67.26	Failed at Hole
	4	42	4	64.3	1.501		0.1297	0.1880	æ	10.40	12.14	62.38	Failed at Hole
	4	42	4	64.3	1.502		0.1297	0.1895	8	10.70	12.80	65.70	Failed at Hole
<u> </u>								Average		10.02	12.67	65.11	
		-						Std. Dev.			0.48	2.49	
								% COV			3.79	3.83	

Load at Ultimate Ultimate Audible Load Stress (kips) (ksi) (ksi) (hsi) (	intec Project #: BH0003	ВН0003			: :		Сошр	arison o	f Laming for Boe	Comparison of Laminated Comp. to Braided Textiles for Boeing Helicopters	ip. to B	Sraided T	extiles			
Mat. Call   Panel   Fiber   Average Dimensions (Inches)   Load at Ultimate Ultimate   Ultimate	Temperature		FH							)	•					
### Minguest     14	intec Engine	.: .:	Maryan	n Eina	arson				Open Ho	le Tension	Resuits					-
Type   Class   Mat.   Cell   Panel   Fiber   Average Dimensions (inches)   Load at Ultimate Ultimate   Ultim	Boeing engin	1897:	Pierre A	Aingue	<del>7</del>											
Type         Class         #         ID         Volume         Width         Length         Thick-less         Hole         W/D         Audible         Load         Stress           OHT         1         48         1A         66.3         1.501         11.5         0.1078         0.2505         6         11.437         69.882         Failed O.H           OHT         1         48         1A         66.3         1.501         11.5         0.1098         0.2505         6         11.437         69.882         Failed O.H           OHT         1         48         1A         66.3         1.501         11.5         0.1098         0.2505         6         11.437         69.882         Failed O.H           OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.118         73.00           OHT         2         49         2A         65.7         1.502         12.0         0.1109         0.2505         6         9.40         11.189         73.00           OHT         2         49         2A         65.7         1.502         12.0         0.1109         0.2	Specimen	Test	Mat.	3	Panel	Fiber	Avera	age Dime	nsions (in	ches)		Load at	Ultimate	Ultimate	Failure Location/	
OHT         1         48         1A         66.3         1.501         11.5         0.1078         0.2505         6         11.880         73.433           OHT         1         48         1A         66.3         1.501         11.5         0.1096         0.2505         6         11.880         73.08           OHT         1         48         1A         66.3         1.501         11.5         0.1096         0.2505         6         11.88         73.00           OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.188         73.00           OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2516         6         9.40         11.150         68.02           OHT         2         49         2A         65.7         1.502         12.0         0.1109         0.2516         6         9.40         11.150         68.02           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2516         6         9.40         11.150         0.41	<u>Ω</u>	Туре	Class	#	<u>Q</u>	Volume	Width	Length		Hole	Q/M	Audible	Load	Stress	Comments	
OHT         1         48         1A         66.3         1.501         11.5         0.1078         0.2505         6         11.880         73.433           OHT         1         48         1A         66.3         1.501         11.5         0.1090         0.2505         6         11.880         73.403           OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.889         73.00           OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.188         73.00           OHT         2         49         2A         65.7         1.502         12.0         0.1091         0.2505         6         9.50         11.188         73.00           OHT         3         50         3A         65.7         1.502         12.0         0.1091         0.2505         6         9.40         11.50         68.80           OHT         3         50         3A         65.8         1.501         11.5         0.1091         0.2505         6         9.40         11.37						%			ness	Dia 1	1	(KIPS)	(KIPS)	(KSI)		Т
OHT         1         48         1A         66.3         1.502         11.5         0.1099         0.2505         6         11.437         69.882           OHT         1         48         1A         66.3         1.501         11.5         0.1095         0.2505         6         11.88         73.00           OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.110         67.282           OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.110         67.282           OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.40         11.110         67.282           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2510         6         9.45         11.37         68.80           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2510         6         7.30         7.13	BH3-179	占	-	4 8	4	66.3	1.501	11.5	0.1078	0.2505	9		11.880	73.433	Failed at Hole	
OHT         1         48         1A         66.3         1.501         11.5         0.1085         0.2505         6         11.88         73.00           OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.110         67.282         0.44         2.92         0.44         2.92         0.44         2.90         0.44         2.90         0.44         2.90         0.44         4.00         0.44         2.92         0.44         4.00         0.44         4.00         0.44         4.00         0.41         2.0         0.1109         0.2505         6         9.50         11.110         67.282         1         0.41         2.0         0.1109         0.2505         6         9.50         11.110         67.282         1         0.41         2.0         0.41         2.0         0.41         2.0         0.41         2.0         0.41         2.0         0.41         0.41         0.0         0.41         0.41         0.0         0.41         0.0         0.41         0.0         0.41         0.0         0.41         0.0         0.41         0.0         0.41         0.0         0.41         <	BH3-180	된	-	48	4	66.3	1.502	11.5	0.1090	0.2505	9		11.437	69.882	Failed at Hole	
Note the continue of the con	BH3-181	둥	-	48	1 A	66.3	1.501	11.5	0.1085	0.2505	و		12.326	/2.6/8	Fашед ат Hоте	T
OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.839         71.103           OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.110         67.282           OHT         2         49         2A         65.7         1.502         12.0         0.1091         0.2505         6         9.40         11.150         68.027           OHT         2         49         2A         65.7         1.502         12.0         0.1091         0.2510         6         9.45         11.10         67.282           OHT         3         65.8         1.501         11.5         0.1147         0.2510         6         7.40         7.154         41.59           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         7.03         7.18         41.69           OHT         4         51         4A         64.3         1.501         11.5         0.1147         0.2505         6         7.03         7.18										Average			11.88	73.00		
OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.139         71.103           OHT         2         49         2A         65.7         1.501         12.0         0.1100         0.2505         6         9.50         11.110         67.282           OHT         2         49         2A         65.7         1.502         12.0         0.1091         0.2510         6         9.40         11.150         68.027           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2510         6         7.40         7.154         41.580           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         7.30         7.113         41.580           OHT         4         51         4A         64.8         1.501         11.5         0.1147         0.2500         6         7.30         7.114         41.59           OHT         4         51         4A         64.8         1.501         11.5         0.1147         0.2500         6										Std. Dev.			0.44	2.92		
OHT         2         49         2A         65.7         1.501         12.0         0.1109         0.2505         6         9.50         11.110         67.282           OHT         2         49         2A         65.7         1.501         12.0         0.1100         0.2505         6         9.50         11.110         67.282           OHT         2         49         2A         65.7         1.502         12.0         0.1091         0.2510         6         9.40         11.150         67.282           OHT         2         49         2A         65.7         1.502         12.0         0.1091         0.2510         6         9.40         11.150         68.027           OHT         3         65.8         1.501         11.5         0.1147         0.2510         6         7.00         7.154         41.580           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         6.39         7.18         41.69           OHT         4         51         4A         64.3         1.501         11.5         0.1147         0.2500         6         6.39         7.18										% COV			3.74	4.00		7
OHT         2         49         2A         65.7         1.501         12.0         0.1100         0.2505         6         9.50         11.110         67.282           OHT         2         49         2A         65.7         1.502         12.0         0.1091         0.2510         6         9.40         11.150         68.027           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         7.40         7.154         41.580           OHT         3         50         3A         65.8         1.501         11.0         0.1150         0.2500         6         7.30         7.113         41.214           OHT         4         51         4A         64.3         1.501         11.5         0.1147         0.2500         6         7.30         7.18         41.69           OHT         4         51         4A         64.3         1.501         11.5         0.1147         0.2500         6         7.03         7.18         41.69           OHT         4         51         4A         64.3         1.502         11.5         0.1305         0.2505         6 <td< td=""><td>BH3-182</td><td>늄</td><td>2</td><td>49</td><td>2 A</td><td>65.7</td><td>1.501</td><td>12.0</td><td>0.1109</td><td>0.2505</td><td>9</td><td></td><td>11.839</td><td>71.103</td><td>Failed at Hole</td><td></td></td<>	BH3-182	늄	2	49	2 A	65.7	1.501	12.0	0.1109	0.2505	9		11.839	71.103	Failed at Hole	
OHT         2         49         2A         65.7         1.502         12.0         0.1091         0.2510         6         9.45         11,150         68.027           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         7.40         7.154         41.580           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         7.30         7.113         41.214           OHT         4         51         4A         65.8         1.501         11.5         0.1147         0.2500         6         7.30         7.113         41.69           OHT         4         51         4A         64.8         1.501         11.5         0.1147         0.2500         6         7.03         7.18         41.69           OHT         4         51         4A         64.3         1.501         11.5         0.1350         0.2505         6         7.03         7.18         41.69           OHT         4         51         4A         64.3         1.502         11.5         0.1350         0.2505         6         1	BH3-183	占	8	49	2A	65.7	1.501	12.0	0.1100	0.2505	9	9.50	11.110	67.282	Failed at Hole	
OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2510         6         7.40         7.154         41.580           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         7.30         7.113         41.214           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         7.30         7.113         41.214           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         7.30         7.113         41.214           OHT         4         51         4A         64.3         1.501         11.5         0.1320         0.2505         6         6.39         7.18         41.69           OHT         4         51         4A         64.3         1.502         11.5         0.1320         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.167	BH3-184	占	Ø	49	2A	65.7	1.502	12.0	0.1091	0.2510	9	9.40	11.150	68.027	Failed at Hole	
OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2510         6         7.40         7.154         41.580           OHT         3         50         3A         65.8         1.501         11.0         0.1147         0.2500         6         7.30         7.154         41.580           OHT         3         50         3A         65.8         1.501         11.0         0.1147         0.2500         6         7.30         7.154         41.580           OHT         4         51         4A         64.3         1.501         11.5         0.147         0.2500         6         7.03         7.18         41.69           OHT         4         51         4A         64.3         1.500         11.5         0.1320         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.502         11.5         0.1315         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.233         61.947 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>Average</td> <td></td> <td>9.45</td> <td>11.37</td> <td>68.80</td> <td></td> <td></td>										Average		9.45	11.37	68.80		
OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2510         6         7.40         7.154         41.580           OHT         3         50         3A         65.8         1.501         11.0         0.1150         0.2500         6         7.30         7.113         41.214           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         6.39         7.277         42.276           Average         7.03         7.18         41.69         7.277         42.276         6           COHT         4         51         4A         64.3         1.500         11.5         0.1320         0.2505         6         12.546         63.339           OHT         4         51         4A         64.3         1.501         11.5         0.1305         0.2505         6         12.546         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.233         61.947           A         51         4A         64.3         1.501				•	-					Std. Dev.			0.41	2.03		
OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         7.40         7.154         41.580           OHT         3         50         3A         65.8         1.501         11.0         0.1150         0.2500         6         7.30         7.113         41.214           OHT         3         65.8         1.501         11.5         0.1147         0.2500         6         6.39         7.277         42.276           Average         7.03         7.18         41.69           Std. Dev.         8.COV         1.19         1.29           OHT         4         51         4A         64.3         1.502         11.5         0.1305         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.502         11.5         0.1305         0.2505         6         12.33         61.947           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.33         62.45           SIG         4         51         4A         64.3										% COV			3.60	2.94		$\neg \exists$
OHT         3         50         3A         65.8         1.501         11.0         0.1150         0.2500         6         7.30         7.113         41.214           OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         6.39         7.277         42.276           Average         7.03         7.18         41.69         7.277         42.276         6           Sid. Dev.         8.00         7.03         7.18         41.69         0.54         1.29           OHT         4         51         4A         64.3         1.500         11.5         0.1305         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.33         61.947           A         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.33         61.94	BH3-185	동	၉	50	3A	65.8	1.501	11.5	0.1147	0.2510	9	7.40	7.154	41.580	Failed at Hole	
OHT         3         50         3A         65.8         1.501         11.5         0.1147         0.2500         6         6.39         7.277         42.276           Average         Average         7.03         7.18         41.69           Std. Dev.         Std. Dev.         0.09         0.54           OHT         4         51         4A         64.3         1.500         11.5         0.1320         0.2505         6         12.546         63.339           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.233         61.947           Average         Average         12.32         62.45           Std. Dev.         1.64         1.23         62.45	BH3-186	동	က	20	34	65.8	1.501	11.0	0.1150	0.2500	9	7.30	7.113	41.214	Failed at Hole	
OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.32         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.546         63.339           OHT         4         51         4A         64.3         1.502         11.5         0.1315         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.167         62.073           SIG. Dev.         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.32         62.45           Average         7         80.0         0.20         0.77         0.20         0.77           Average         80.0         1.64         1.23         6.24         1.23	BH3-187	늄	ო	20	34	65.8	1.501	11.5	0.1147	0.2500	9	6.39	7.277	42.276	Failed at Hole	7
OHT 4 51 4A 64.3 1.500 11.5 0.1350 0.2505 6 12.546 63.339 OHT 4 51 4A 64.3 1.501 11.5 0.1315 0.2505 6 12.167 62.073 OHT 4 51 4A 64.3 1.501 11.5 0.1315 0.2505 6 12.233 61.947  Std. Dev. 0.20 0.77  Average 0.20 0.77  Std. Dev. 1.64 1.23										Average		7.03	7.18	41.69		
OHT         4         51         4A         64.3         1.502         11.5         0.1320         0.2505         6         12.546         63.339           OHT         4         51         4A         64.3         1.502         11.5         0.1305         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.233         61.947           Std. Dev.         Average         12.33         61.947         62.45           Std. Dev.         Std. Dev.         0.20         0.77           Accov         1.64         1.23						•				Std. Dev.			60.0	0.54		
OHT         4         51         4A         64.3         1.500         11.5         0.1305         0.2505         6         12.546         63.339           OHT         4         51         4A         64.3         1.502         11.5         0.1305         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.233         61.947           Average         12.32         62.45           Std. Dev.         0.20         0.77           %COV         1.64         1.23				-						% COV			1.19	1.29		
OHT         4         51         4A         64.3         1.502         11.5         0.1315         0.2505         6         12.167         62.073           OHT         4         51         4A         64.3         1.501         11.5         0.1315         0.2505         6         12.233         61.947           Average         Average         12.32         62.45           Std. Dev.         0.20         0.77           %COV         1.64         1.23	BH3-188	동	4	51	4 A	64.3	1.500	11.5	0.1320	0.2505	9		12.546	63.339	Failed at Hole	
OHT 4 51 4A 64.3 1.501 11.5 0.1315 0.2505 6 12.233 61.947  Average 12.233 61.947  Average 0.20 0.77  Std. Dev. 0.20 0.77  %COV 1.64 1.23	BH3-189	동	4	51	4 A	64.3	1.502	11.5	0.1305	0.2505	9		12.167	62.073	Failed at Hole	
Average 12.32 Std. Dev. 0.20 %COV 1.64	BH3-190	늄	4	51	4 A	64.3	1.501	11.5	0.1315	0.2505	9		12.233	61.947	Failed at Hole	
w. 0.20										Average			12.32	62.45		
1.64						•••				Std. Dev.			0.20	0.77		
										% COV			1.64	1.23		$\neg$

Inter-Engineer:   Maryann Ennañon   Pierre Minguelt   Pierre Min	intec Project #: BH0003	ВН0003			:		Сотра	ırison of	Lamina for Boe	Laminated Comp. to B for Boeing Helicopters	p. to B opters	Comparison of Laminated Comp. to Braided Textiles for Boeing Helicopters	extiles			
Maryann Einarson   Character	Temperature		ВŢ													
Mai. Cell Panel Fiber	intec Engine	.: -	Maryan	n Eina	rson			Open	Hole Trar	nsverse Te	nsion R	esults				
Type   Class   Hole   Fiber   Average Dimensions (Inches)   Load at Ultimate   Ultimat	Boeing engin	1997:	Pierre	Mingue	<b>=</b>											
Type	Specimen	Test	Mat.	$\vdash$	Panel	Fiber	Avera	ige Dimei	nsions (in	ches)		Load at	Ultimate	Ultimate	Failure Location/	
OHIT         1         4         1B         66.9         1.503         12.0         0.1081         0.2515         6         2.50         5.037         31.00           OHIT         1         4         1B         66.9         1.503         12.0         0.1081         0.2515         6         2.50         5.037         31.00           OHIT         1         4         1B         66.9         1.503         12.0         0.1087         0.2516         6         2.60         5.037         31.00           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         none         8.987         55.54           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         none         9.519         58.66           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         8.60         9.16         5.796           OHIT         3         30         3B         66.2         1.502         12.0         0.1129         0.2510         6	<u></u>	Туре	Class		Ω	Volume	Width	Length	Thick-	Hole	Q/ <b>M</b>	Audible (Kins)	Load (kips)	Stress (ksi)	Comments	
OHTI         1         4         1B         66.9         1.503         12.0         0.1081         0.2515         6         2.50         5.037         31.00           OHTI         1         4         1B         66.9         1.503         12.0         0.1087         0.2510         6         3.10         4.811         29.46           OHTI         2         56         2A         65.7         1.500         12.0         0.1079         0.2520         6         none         9.519         58.68           OHTI         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         none         9.519         58.68           OHTI         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         none         9.519         58.68           OHTI         3         30         3B         66.2         1.500         12.0         0.1072         0.2520         6         8.60         9.16         56.69           OHTI         3         30         3B         66.2         1.502         12.0         0.1128         0.2516         6 <th< td=""><td>9</td><td>į</td><td>Į.</td><td>1</td><td>Ģ</td><td>(%)</td><td>1 503</td><td>120</td><td>0 1072</td><td>0.2515</td><td>9</td><td>3.00</td><td>4.810</td><td>29.87</td><td>Hole</td><td></td></th<>	9	į	Į.	1	Ģ	(%)	1 503	120	0 1072	0.2515	9	3.00	4.810	29.87	Hole	
OHTI         1         4         1B         66.9         1.503         12.0         0.1087         0.2510         6         3.10         4.811         29.46           OHTI         2         56         2A         65.7         1.500         12.0         0.1079         0.2520         6         none         8.987         55.54           OHTI         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         none         8.987         55.54           OHTI         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         none         8.987         55.54           OHTI         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         none         8.987         55.66           OHTI         3         30         3B         66.2         1.500         12.0         0.1129         0.2510         6         8.60         9.16         5.716         33.07           OHTI         3         30         3B         66.2         1.502         12.0         0.1128         0.2510		= E	- •	4 <	ā	6.00	1.503	12.0	0.1081	0.2515	9	2.50	5.037	31.00	Hole	
OHTT         2         56         2A         6.5.7         1.500         12.0         0.1079         0.2520         6         none         8.987         55.54           OHTT         2         56         2A         65.7         1.500         12.0         0.1079         0.2520         6         none         8.987         55.54           OHTT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         none         8.987         55.86           OHTT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         none         9.516         55.86           OHTT         3         30         3B         66.2         1.500         12.0         0.1129         0.2510         6         8.60         9.16         5.719         33.04           OHTT         3         30         3B         66.2         1.502         12.0         0.1129         0.2510         6         5.719         33.04           OHTT         4         43         4B         66.2         1.502         12.0         0.1128         0.2510         6		5 5		t 4	<u> </u>	6.99	1.503	12.0	0.1087	0.2510	9	3.10	4.811	29.46	Hole	
OHIT         2         56         2A         65.7         1.500         12.0         0.1079         0.2520         6         none         8.987         55.54           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         none         9.519         56.58           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         8.60         8.982         55.86           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         8.60         9.16         56.89           OHIT         3         30         3B         66.2         1.503         12.0         0.1129         0.2510         6         8.60         9.16         57.19         33.7           OHIT         3         30         3B         66.2         1.502         12.0         0.1128         0.2516         6         8.60         9.16         5.719         33.421           OHIT         4         4.3         4B         66.4         1.502         12.0         0.1128	BH3-0/3	5	-	·	2					Average		2.87	4.89	30.11		
OHIT         2         56         2A         65.7         1.500         12.0         0.1079         0.2520         6         none         8.987         55.54           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         8.60         8.987         55.54           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         8.60         8.987         55.54           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         8.60         8.982         55.86           OHIT         3         30         3B         66.2         1.503         12.0         0.1129         0.2510         6         8.60         9.16         56.69           OHIT         3         30         3B         66.2         1.502         12.0         0.1129         0.2510         6         5.719         33.7           OHIT         3         30         3B         66.2         1.502         12.0         0.1128         0.2510         6         5.749         <										Std. Dev.			0.13	0.80		
OHIT         2         56         2A         65.7         1.500         12.0         0.1079         0.2550         6         none         8.987         55.54           OHIT         2         56         2A         65.7         1.500         12.0         0.1082         0.2550         6         8.60         8.982         55.86           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2550         6         8.60         8.982         55.86           OHIT         3         30         38         66.2         1.500         12.0         0.1129         0.2510         6         8.60         9.16         56.69           OHIT         3         30         38         66.2         1.502         12.0         0.1129         0.2510         6         5.719         33.74         33.84           OHIT         3         30         38         66.2         1.502         12.0         0.1128         0.2510         6         5.719         33.74         33.92           OHIT         4         43         48         66.2         1.502         12.0         0.1128         0.2510         6										% COV			2.67	2.65		Т
OHIT         2         56         2A         65.7         1.500         12.0         0.1082         0.2520         6         8.60         8.982         55.86           OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         8.60         8.982         55.86           OHIT         3         30         3B         66.2         1.502         12.0         0.1129         0.2510         6         8.60         9.16         56.69           OHIT         3         30         3B         66.2         1.502         12.0         0.1129         0.2510         6         5.719         33.74         33.84           OHIT         3         30         3B         66.2         1.502         12.0         0.1128         0.2510         6         5.719         33.74           OHIT         4         43         4B         66.2         1.502         12.0         0.1128         0.2510         6         5.795         34.21           OHIT         4         43         4B         66.4         1.502         12.0         0.1286         0.2505         6         11.04         11.04	700 0110	1	,	5.6	2.4	65.7	1.500	12.0	0.1079	0.2520	9	none	8.987	55.54	Hole	
OHIT         2         56         2A         65.7         1.500         12.0         0.1072         0.2520         6         8.60         8.982         55.86           OHIT         3         30         38         66.2         1.500         12.0         0.1129         0.2510         6         9.16         56.69           OHIT         3         30         38         66.2         1.502         12.0         0.1129         0.2510         6         5.719         33.84           OHIT         3         30         38         66.2         1.502         12.0         0.1128         0.2510         6         5.716         33.84           OHIT         4         43         48         66.2         1.502         12.0         0.1128         0.2510         6         5.74         33.92           OHIT         4         43         48         66.4         1.508         12.0         0.1286         0.2505         6         11.04         0.77           OHIT         4         43         48         66.4         1.503         12.0         0.1287         0.2515         6         11.04         11.099         56.15           OHIT <t< td=""><td>BH3-204</td><td>5 5</td><td>4 0</td><td>ט ע</td><td><b>₹</b></td><td>65.7</td><td>1.500</td><td>12.0</td><td>0.1082</td><td>0.2515</td><td>9</td><td>none</td><td>9.519</td><td>58.68</td><td>Hole</td><td></td></t<>	BH3-204	5 5	4 0	ט ע	<b>₹</b>	65.7	1.500	12.0	0.1082	0.2515	9	none	9.519	58.68	Hole	
OHTT         3         30         38         66.2         1.503         12.0         0.1129         0.2510         6         9.16         56.69           OHTT         3         30         38         66.2         1.503         12.0         0.1129         0.2510         6         5.719         33.74           OHTT         3         30         38         66.2         1.502         12.0         0.1128         0.2510         6         5.719         33.84           OHTT         3         30         38         66.2         1.502         12.0         0.1128         0.2510         6         5.716         33.84           OHTT         4         4.3         4B         66.4         1.502         12.0         0.1286         0.2505         6         5.74         33.92           OHTT         4         4.3         4B         66.4         1.508         12.0         0.1287         0.2505         6         11.040         56.94           OHTT         4         4.3         4B         66.4         1.502         12.0         0.1287         0.2515         6         11.040         56.94           OHT         4         4.3 <td< td=""><td>207-5HB</td><td>5 5</td><td>4 0</td><td>ט ע</td><td>0 A</td><td>65.7</td><td>1.500</td><td>12.0</td><td>0.1072</td><td>0.2520</td><td>9</td><td>8.60</td><td>8.982</td><td>55.86</td><td>Hole</td><td>П</td></td<>	207-5HB	5 5	4 0	ט ע	0 A	65.7	1.500	12.0	0.1072	0.2520	9	8.60	8.982	55.86	Hole	П
OHTT         3         30         38         66.2         1.502         12.0         0.1129         0.2510         6         5.719         33.7         3.05           OHTT         3         30         38         66.2         1.502         12.0         0.1125         0.2515         6         5.716         33.84           OHTT         3         30         38         66.2         1.502         12.0         0.1125         0.2515         6         5.716         33.84           OHTT         3         30         38         66.2         1.502         12.0         0.1128         0.2510         6         5.795         34.21           OHTT         4         43         48         66.2         1.502         12.0         0.1286         0.2505         6         0.78         0.78           OHTT         4         43         48         66.4         1.503         12.0         0.1286         0.2505         6         11.040         56.94           OHTT         4         43         48         66.4         1.503         12.0         0.1287         0.2515         6         11.04         11.096         56.94           OHTT         <	BH3-200	5	1	2	7					Average		8.60	9.16	56.69		
OHTT         3         30         38         66.2         1.502         12.0         0.1129         0.2510         6         5.719         33.70           OHTT         3         30         38         66.2         1.502         12.0         0.1125         0.2510         6         5.716         33.84           OHTT         3         30         38         66.2         1.502         12.0         0.1128         0.2510         6         5.716         33.84           OHTT         4         43         48         66.2         1.502         12.0         0.1128         0.2510         6         5.795         34.21           OHTT         4         43         48         66.4         1.508         12.0         0.1286         0.2505         6         11.04         11.099         56.15           OHTT         4         43         48         66.4         1.502         12.0         0.1287         0.2515         6         11.04         11.099         56.86           OHTT         4         43         48         66.4         1.502         12.0         0.1316         0.2510         6         11.04         11.099         56.86										Std. Dev.			0.31	1.73		
OHTT         3         30         3B         66.2         1.503         12.0         0.1129         0.2510         6         5.719         33.70           OHTT         3         30         3B         66.2         1.502         12.0         0.1128         0.2510         6         5.716         33.84           OHTT         4         43         4B         66.2         1.502         12.0         0.1128         0.2510         6         5.74         33.92           OHTT         4         43         4B         66.4         1.508         12.0         0.1286         0.2505         6         11.04         11.099         56.94           OHTT         4         43         4B         66.4         1.503         12.0         0.1287         0.2515         6         11.04         11.099         56.15           OHTT         4         43         4B         66.4         1.503         12.0         0.1287         0.2515         6         11.04         11.099         56.15           OHTT         4         43         4B         66.4         1.502         12.0         0.1316         0.2510         6         11.04         11.09         56.15										% COV			3.37	3.05		т
OHIT         3         30         3B         66.2         1.502         12.0         0.1125         0.2515         6         5.716         33.84           OHIT         3         30         3B         66.2         1.502         12.0         0.1128         0.2510         6         5.795         34.21           OHIT         4         43         4B         66.4         1.508         12.0         0.1286         0.2515         6         11.04         56.94           OHIT         4         43         4B         66.4         1.503         12.0         0.1287         0.2515         6         11.04         11.099         56.80           OHIT         4         43         4B         66.4         1.503         12.0         0.1287         0.2515         6         11.04         11.099         56.15           OHIT         4         43         4B         66.4         1.503         12.0         0.1316         0.2510         6         11.04         11.099         56.15           OHIT         4         43         4B         66.4         1.503         12.0         0.1316         0.2510         6         11.04         11.09         56.15	000	Ę	,	ç	ac	66.2	1 503	12.0	0.1129	0.2510	9		5.719	33.70	Hole	
OHIT         3         30         3B         66.2         1.502         12.0         0.1128         0.2510         6         5.795         34.21           OHIT         4         43         4B         66.4         1.508         12.0         0.1286         0.2515         6         11.040         56.94           OHIT         4         43         4B         66.4         1.503         12.0         0.1287         0.2515         6         11.04         11.099         56.15           OHIT         4         43         4B         66.4         1.503         12.0         0.1287         0.2515         6         11.04         11.099         56.15           OHIT         4         43         4B         66.4         1.503         12.0         0.1316         0.2515         6         11.04         11.099         56.15           OHIT         4         43         4B         66.4         1.503         12.0         0.1316         0.2510         6         11.08         11.08         56.80           Std. Dev.         8         6         11.08         11.08         56.80         10.03         0.03         0.60           Std. Dev.	BH3-097	<u> </u>	, (	2 6	g &	66.1	1 502	12.0	0.1125	0.2515	9		5.716	33.84	Hole	
OHIT         4         43         4B         66.4         1.502         12.0         0.1316         0.2510         6         11.04         5.73         33.92           OHTT         4         43         4B         66.4         1.503         12.0         0.1287         0.2515         6         11.04         11.089         56.94           OHTT         4         43         4B         66.4         1.502         12.0         0.1316         0.2516         6         11.04         11.099         56.15           OHTT         4         43         4B         66.4         1.502         12.0         0.1316         0.2516         6         11.04         11.099         56.15           OHTT         4         43         4B         66.4         1.502         12.0         0.1316         0.2510         6         11.08         11.08         56.15           OHTT         4         43         4B         66.4         1.502         12.0         0.1316         0.2510         6         11.08         56.15           OHTT         4         43         4B         66.4         1.502         12.0         0.1316         0.2510         6         11.08	BH3-088	5 E	, (	2 6	3 6	66.1	1.502	12.0	0.1128	0.2510	9		5.795	34.21	Hole	
OHTT 4 43 4B 66.4 1.508 12.0 0.1286 0.2505 6 10.87 11.040 56.94 0.77 OHTT 4 43 4B 66.4 1.502 12.0 0.1316 0.2510 6 11.04 11.099 56.15 OHTT 4 43 4B 66.4 1.502 12.0 0.1316 0.2510 6 11.04 11.099 56.15 OHTT 4 43 4B 66.4 1.502 12.0 0.1316 0.2510 6 11.04 11.099 56.15 OHTT 4 0.2510 6 11.04 11.04 11.05 OHTT 4 0.2510 6 11.04 11.05 OHTT 4 0.2510 6 11.04 11.05 OHTT 4 0.2510 6 11.05 OHTT 4 0.2510 OHTT 4 0.	BH3-088	5	,	3	3					Average			5.74	33.92		
OHTT         4         43         4B         66.4         1.508         12.0         0.1286         0.2505         6         11.040         56.94           OHTT         4         43         4B         66.4         1.503         12.0         0.1287         0.2515         6         10.87         11.088         57.33           OHTT         4         43         4B         66.4         1.502         12.0         0.1316         0.2510         6         11.04         11.099         56.15           OHTT         4         43         4B         66.4         1.502         12.0         0.1316         0.2510         6         11.04         11.099         56.15           SIG         8         8         66.4         1.502         12.0         0.1316         0.2510         6         11.08         56.15           SIG         9         8         8         8         6         10.96         11.08         56.80           SIG         9         8         8         8         6         10.96         11.08         10.06           9         9         9         8         8         9         9         9         9										Std. Dev.			0.04	0.26		
OHTT         4         43         4B         66.4         1.508         12.0         0.1286         0.2505         6         10.87         11.040         56.94           OHTT         4         43         4B         66.4         1.503         12.0         0.1287         0.2515         6         10.87         11.088         57.33           OHTT         4         43         4B         66.4         1.502         12.0         0.1316         0.2510         6         11.04         11.099         56.15           OHTT         4         43         4B         66.4         1.502         12.0         0.1316         0.2510         6         11.04         11.099         56.15           Std. Dev.         Std. Dev.         50.03         0.60         0.28         1.06										% COV			0.78	0.77		
OHIT 4 43 4B 66.4 1.503 12.0 0.1287 0.2515 6 10.87 11.088 57.33 OHIT 4 43 4B 66.4 1.502 12.0 0.1316 0.2510 6 11.04 11.099 56.15 OHIT 4 43 4B 66.4 1.502 12.0 0.1316 0.2510 6 11.04 11.099 56.15 OHIT 4 63 4B 66.4 1.502 12.0 0.1316 0.2510 6 11.08 56.80 Std. Dev. 0.03 0.60	00,0	Į		5	A B	66.4	1 508	12.0	0.1286	┺	9		11.040	56.94	Hole	
OHIT 4 43 4B 66.4 1.502 12.0 0.1316 0.2510 6 11.04 11.099 56.15  OHIT 4 43 4B 66.4 1.502 12.0 0.1316 0.2510 6 11.04 11.099 56.15  Average 10.96 11.08 56.80 0.60  Std. Dev. 0.03 0.60	BH3-109		t <	7 7	4 4	66.4	1.503	12.0	0.1287		9	10.87	11.088	57.33	Hole	
Average 10,96 11.08 Std. Dev. 0.03 % COV 0.28	873-110			7	4 4	66.4	1.502	12.0	0.1316			11.04	11.099	56.15	Hole	Т
0.03	BH3-111	5	*	3	-					-		10,96	11.08	56.80		
0.28										Std. Dev.			0.03	09.0		
										% CO			0.28	1.06		7

intec														
Project #: BH0003	ВН0003					Сошр	arison o	f Lamin	Comparison of Laminated Comp. to Braided Textiles	np. to E	3raided 7	extiles		
								for Boe	for Boeing Helicopters	opters	<i>(</i> C			
Temperature:		H												
intec Engineer:	er:	Maryann Einarson	in Ein	arson			Open	Hole Tra	Open Hole Transverse Tension Results	Insion F	<b>Besults</b>			
Boeing engineer:	: 1991:	Pierre Minguet	Mingu	et et			ı							
Specimen	Test	Mat	3	Panel	Fiber	Avera	ige Dime	Average Dimensions (inches)	iches)		Load at	Ultimate	Ultimate	Failure Location/
Ω	Туре	Class	#	<u>Q</u>	Volume	Width	Length	_	Hole	M/D	Audible	Load	Stress	Comments
	Ţ				%			ness	Ula 1		(kips)	(KIPS)	(KSI)	
BH3-121	F	-	53	4	66.3	1.503	12.0	0.1081	0.1885	9	2.50	5.39	33.18	Hole/ delamination
BH3-122	PHT FHT	-	53	<u> </u>	66.3	1.502	12.0	0.1077	0.1885	9	2.45	5.47	33.79	Hole/ delamination
BH3-123	유크	1	53	1 A	66.3	1.502	12.0	0.1068	0.1885	9	2.95	5.52	34.40	Hole/ delamination
									Average		2.63	5.46	33.79	
									Std. Dev.			90.0	0.61	
									% COV			1.18	1.79	
BH3-085	표정	2	11	2B	0.99	1.503	12.0	0.1048	0.1885	8	9.20	10.59	67.23	Hole/ delamination
BH3-086	FE	N	17	28	0.99	1.503	12.0	0.1054	0.1890	80	9.35	10.54	66.58	Hole/ delamination
BH3-087	유크	2	17	2B	0.99	1.503	12.0	0.1066	0.1890	8	9.75	9.94	62.08	Hole/ delamination
									Average		9.43	10.36	65.30	
									Std. Dev.			0.36	2.80	
									% COV			3.50	4.29	
	H	က	54	3 A		1.501	12.0	0.1129	0.1885	9		60.9	35.93	Hole/ delamination
	FF	ო	54	3A	65.8	1.501	12.0	0.1143	0.1885	9		6.07	35.34	Hole/ delamination
BH3-126	ᆵ	3	54	3A		1.502	12.0	0.1144	0.1885	9		6.02	35.06	Hole/ delamination
								7	Average			90.9	35.44	
									Std. Dev.			0.03	0.44	
								-	% COV			0.51	1.25	
BH3-127	FF	4	55	4 A	64.3	1.502	12.0	0.1295	0.1885	9	11.75	12.47	64.13	Hole/ delamination
BH3-128	FF	4	55	4 A	64.3	1.500	12.0	0.1292	0.1885	9	10.15	12.02	61.98	Hole/ delamination
BH3-129	어디	4	55	44	64.3	1.501	12.0	0.1282	0.1885	9	11.05	11.61	60.28	Hole/ delamination
									Average		10.98	12.03	62.13	
									Std. Dev.			0.43	1.93	
									% COV			3.58	3.10	

	Project #: BRUUUG				O	Comparison of Laminated Composites to Braided Textines for Boeing Helicopters	1 5 5	for Boe	for Boeing Helicopters	opters			
Temperature: intec Engineer: Boeing engineer:	Ľ	RT Maryann Einarson Pierre Minguet	n Eina Aingue	rson				Filled Ho	Filled Hole Tension Results	Results			
Specimen	Test	Mat.	8	Panel	Fiber	Avera	Average Dimensions (inches)	ni) suoist	ches)	Load at	Ultimate	Ultimate	Failure Mode/
	Туре	Class	*	۵	Volume	Width	Length	Thick	Hoe.	Audible	Load	Stress	Comments
4		:	1	1	8	1	]	Seu	Lia	(KIPS)	(KIPS)	(KSI)	Capitro Mode/
neu	Test	Mat.	 ₹	Panel	- Ped	Avera	Average Dimensions (inches)	Sions (In	cnes)	Load at	Ollinale	Ollinate	Candle Mode
	Туре	Class	#	۵	Volume (%)	Width	Length	Thick	Hole Dia 1	Audible (kips)	Load (kips)	Stress (ksi)	Comments
RH3-007	뒲	-	9	4	66.3	1.503	11.5	0.1094	0.2515	8.45	10.49	63.82	Fastener/delamination
	Ħ	-	10	4	66.3	1.501	11.5	0.1092	0.2510	9.35	10.58	64.57	Fastener/delamination
	Ξ	-	10	4	66.3	1.502	11.5	0.1106	0.2495	8.80	10.17	61.26	Fastener/delamination
1									Average	8.87	10.41	63.22	
									Std. Dev.		0.25	1.74	
									% COV		2.07	2.75	
BH3-025	臣	2	23	2A	65.7	1.501	12.0	0.1067	0.2505	8.00	8.32	51.97	Fastener/delamination
	E	8	23	2 <b>A</b>	65.7	1.502	12.0	0.1078	0.2505	6.75	8.51	52.58	Fastener/delamination
	Ħ	\ \	23	2A	65.7	1.501	12.0	0.1085	0.2500	7.80	8.62	52.94	Fastener/delamination
╄									Average	7.52	8.48	52.50	
			•						Std. Dev.		0.15	0.49	
						•			% COV		1.76	0.94	
BH3-043	E	က	36	34	65.8	1.502	11.5	0.1149	0.2520	5.15	7.45	43.18	Fastener
	E	ო	36	3A	65.8	1.503	11.5	0.1144	0.2515	5.70	7.84	45.64	Fastener
	Ŧ	6	36	34	65.8	1.503	11.5	0.1149	0.2500	5.90	7.54	43.65	Fastener
╄									Average	5.58	7.61	44.16	
									Std. Dev.		0.20	1.31	
									% COV		2.69	2.97	
BH3-061	左	4	49	4 A	64.3	1.505	11.5	0.1303	0.2505	8.20	9.74	49.67	Fastener
_	H	4	49	4 A	64.3	1.502	11.5	0.1304	0.2515	9.23	9.84	50.20	Fastener
	Ŧ	4	49	4 A	64.3	1.502	11.5	0.1296	0.2505	8.55	9.19	47.22	Fastener
1_									Average	8.66	9.59	49.03	
									Std. Dev.		0.35	1.59	
									% 00 %		3.64	3.25	

intec Project#: BH0003	BH0003	_			0	Sompari	son of L	aminate	d Compo	sites to B	Comparison of Laminated Composites to Braided Textiles	ctiles		1
Temperature: intec Engineer: Boeing engineer:	e: эег: neer:	RT Maryann Einarson Pierre Minguet	n Ein: Mingu	arson et			Filler	Hole Tra	ior boeing nencopiers Hole Transverse Tension R	ior boeing nencopiers Filled Hole Transverse Tension Results	its			
Specimen	Test	Mat.	3	Panel	Fiber	Aver	age Dime	Average Dimensions (inches)	ches)	Load at	Ultimate	Ultimate	Failure Mode/	
<u>Ω</u>	Туре	Class	*	<u>Q</u>	Volume	Width	Length	Thick	Hole	Audible	Load	Stress	Comments	
				,	(%)			ness	Dia 1	(kips)	(kips)	(ksi)		
BH3-079	딾	1	1-	18	6.99	1.503	12.0	0.1080	0.2510	3.65	5.73	35.30	Fastener delamination/ spark	V
BH3-080	H	-	-	18	6.99	1.502	12.0	0.1083	0.2520	3.40	5.71	35.11	Fastener delamination	
BH3-081	표	1	11	1B	6.99	1.503	12.0	0.1061	0.2515	3.15	5.50	34.48	Fastener delamination	-
									Average	3.40	5.65	34.96		
				•					Std. Dev.		0.13	0.43		
									% COV		2.30	1.22		
BH3-091	FHT	2	24	2B	0.99	1.502	12.0	0.1062	0.2505	7.20	8.35	52.38	Fastener delamination	
BH3-092	E	7	24	28	0.99	1.502	12.0	0.1051	0.2510	5.95	8.80	55.79	Fastener delamination	
BH3-093	E	8	24	2B	0.99	1.501	12.0	0.1066	0.2500	7.90	8.83	55.19	Fastener delamination	
									Average	7.02	99.8	54.45		
									Std. Dev.		0.27	1.83		
									% COV		3.10	3.35		
BH3-103	표	က	37	38	66.2	1.503	12.0	0.1117	0.2515	4.10	5.91	35.19	Fastener delamination	
BH3-104	표	က	37	3B	66.2	1.502	12.0	0.1115	0.2515	3.85	5.91	35.27	Fastener delamination	
BH3-105	표	က	37	38	66.2	1.502	12.0	0.1116	0.2520	3.75	5.96	35.52	Fastener delamination	
									Average	3.90	5.95	35.32		
									Std. Dev.		0.03	0.17		
									% COV		0.48	0.49		
BH3-115	E	. 4	20	48	66.4	1.502	12.0	0.1296	0.2515	5.62	10.65	54.70	Fastener delamination	
BH3-116	표	4	20	48	66.4	1.503	12.0	0.1283	0.2515	7.85	10.75	55.75	Fastener delamination	
BH3-117	HH	4	50	48	66.4	1.502	12.0	0.1283	0.2500	8.60	10.14	52.66	Fastener delamination	
									Average	7.36	10.51	54.37		
									Std. Dev.		0.32	1.57		
			•						% COV		3.08	2.90		

•	Project#: BH0003				Com	parison (	of Lamin for Boo	Laminated Comp. to B for Boeing Helicopters	p. to Braic opters	mparison of Laminated Comp. to Braided Textiles for Boeing Helicopters				
Temperature:	:: en	ТĦ												
intec Engineer:		Maryan	Maryann Einarson	5			IITRI Co	IITRI Compression Results	Results					
Boeing Engineer:	neer:	Pierre Minguet	<b>dinguet</b>										Chord	
Specimen	Test	Mat	Panel	Fiber	Average	Dim. (in)	Load at	Ultimate	Ultimate	Ult. Axial	Ult. Axial	Ultimate	Ave. Axia	Poisson's
9	Type		۵	So.			Audible	Load	Stress	Strn #1	Strn#2	Trans. Strn	Modulus	Ratio
!				8		SSOU	(kips)	(kips)	(ksi)	(311)	(3π)	(Эп)	(MPSI)	
Specimen	Test	Mat	Panel	Fiber	Average	Dim. (in)	Load at	Ultimate	Ultimate	Ult. Axial	Ult. Axial	Ultimate	Ave. Axia	Poisson's
2	Tvpe	_	Ω	Ş Ş	Width	Thick	Audible	Load	Stress	Strn #1	Strn#2	Trans. Strn	Modulus	Ratio
)			)	(%)		ness	(kips)	(kips)	(ksi)	(3π)	(πε)	(Эп)	(MPSI)	
RH3-136	Œ	-	2	57.5	1.498	0.2502	26.80	27.091	72.302	2088-	-9691	6985	8.37	0.705
BH3-137		-	<u> </u>	57.5	1.497	0.2496	29.70	30.083	80.518	-8226	-11229	7242	8.46	0.724
BH2-138	<u> </u>		2	57.5	1.499	0.2488	30.40	33.089	88.742	-11541	-12158	8498	8.58	0.682
201						Average	28.97	30.09	80.52	856'6-	-11,026	7,575	8.47	0.703
						Std. Dev.		3.00	8.22				0.11	0.021
						\ \ \ \ \		9.97	10.21				1.24	2.98
RH3-148	E	2	g	57.9	1.498	0.2469	27.60	27.708	74.939	-9210	-9347	1678	8.33	0.173
BH3-149		۱ ۵	၃	57.9	1.497	0.2455	30.40	30.632	83.338	-11204	-11799	1910	8.15	0.169
BH3-150		۱۵	2	57.9	1.498	0.2462	29.40	30.396	82.417	-9774	-12147	1726	8.48	0.1/5
	1					Average	29.13	29.58	80.23	-10,063	-11,098	1,771	8.32	0.173
						Std. Dev.		1.62	4.61				0.17	0.003
						80%		5.49	5.74				1.99	<u>-</u>
RH3-198	Ē	6	30	59.6	1.500	0.2469	none	21.804	58.860	-23890	-21199	18937	4.25	0.686
BH3-199		· m	30	59.6	1.499	0.2471	19.10	19.930	53.818	-20553	-17429	16287	4.14	0.726
BH3-200		_ m	30	59.6	1.498	0.2490	none	21.804	58.454	ηa	па	na	4.23	0.725
						Average	19.10	21.18	57.04	-22,222	-19,314	17,612	4.21	0.713
						Std. Dev.		1.08	2.80				90.0	0.023
_						% 00 8		5.11	4.91				1.39	3.19
BH3-179	1	4	40	58.3	1.498	0.2974	32.90	34.065	76.481	-12396	-12539	2469	7.07	0.225
BU3-173	Ē	4	4C	58.3	1.497	0.2968	28.90	33.727	75.909	-12226	-12313	2406	7.14	0.221
BH3-174		4	40	58.3	1.499	0.2982	29.30	34.515	77.206	-11437	-12881	2885	6.90	0.234
	1					Average	30.37	34.10	76.53	-12,020	-12,578	2,587	7.04	0.226
						Std. Dev.		0.40	0.65				0.12	0.00.0 2.89
						% CO		1.16	0.03					

intec														
Project #: BH0003	10003				Com	parison (	of Lamin for Boo	Laminated Comp. to B for Boeing Helicopters	p. to Brain opters	nparison of Laminated Comp. to Braided Textiles for Boeing Helicopters				
Temperature:	ш.	НТ						1						
intec Engineer:		Aaryanr	Maryann Einarson	5		HTH	i Transver	se Compre	IITRI Transverse Compression Results	ļ\$				
Boeing Engineer:		Pierre Minguet	linguet										Chord	
Specimen	Test	Mat.	Panel	Fiber	Average	Dim. (in)	Load at	Ultimate	Ultimate	Ult. Axial	Ult. Axial	Ultimate	Ave. Axia	Poisson's
		Class	Ω	Vol.	Width	Thick	Audible	Load	Stress	Strn #1	Strn#2	Trans. Strn	Modulus	Ratio
				(%)		ness	(kips)	(kips)	(ksi)	(311)	(πε)	(эп)	(MPSI)	
BH3-133 III	IITRI-T	-	10	57.5	1.500	0.2474	none	18.613	50.176	-18137	-17984	3838	3.04	0.232
BH3-134 IIT	ITRI-T	_	5	57.5	1.499	0.2496	none	16.872	45.112	-14689	-17507	3759	2.98	0.242
BH3-135 IIT	ITH-T	-	5	57.5	1.498	0.2477	none	17.972	48.444	-16199	-17699	3953	3.03	0.238
						Average		17.82	47.91	-16,342	-17,730	3,850	3.02	0.237
						Std. Dev.		0.88	2.57				0.03	0.005
						% COV		4.94	5.37				1.07	2.20
BH3-145 IIT	ITRI-T	2	2C	57.9	1.499	0.2489	20.80	21.866	58.607	-10144	-11437	1388	7.65	0.146
BH3-146 IIT	ITRI-T	7	20	57.9	1.498	0.2476	26.30	27.947	75.383	-8368	-10035	1290	7.62	0.145
BH3-147 IIT	ITRI-T	2	20	57.9	1.498	0.2474	24.00	25.694	69.333	-7645	-9715	1281	7.50	0.163
						Average	23.70	25.17	67.77	988'8-	-10,396	1,320	7.59	0.151
					<u> </u>	Std. Dev.		3.07	8.50				0.08	0.010
					-	% COV		12.21	12.54				1.05	6.39
BH3-192 III	IITRI-T	3	3D	59.6	1.498	0.2484	none	17.744	47.697	-19194	na	11401	3.05	0.540
BH3-193 IIT	ITRI-T	ო	30	59.6	1.494	0.2497	17.50	17.998	48.257	na	-17402	na	3.06	0.518
BH3-194 III	ITRI-T	3	3D	59.6	1.498	0.2463	попе	17.506	47.452	-19188	na	na	3.01	0.517
						Average	17.50	17.75	47.80	161,61-	-17,402	11,401	3.04	0.525
						Std. Dev.		0.25	0.41				0.03	0.013
						% cov		1.39	0.86				0.87	2.47
BH3-169 III	ITRI-T	4	<del>2</del>	58.3	1.498	0.2989	29.60	31.792	71.004	-10442	-10473	2113	7.21	0.216
BH3-170 IIT	IITRFT	4	4	58.3	1.498	0.2985	попе	31.630	70.756	-10107	-10651	2173	7.24	0.232
BH3-171 IIT	IITRI-T	4	4C	58.3	1.497	0.3000	29.80	32.468	72.284	-10059	-11142	2255	7.43	0.231
					_	Average	29.70	31.96	71.35	-10,203	-10,755	2,180	7.29	0.227
						Std. Dev.		0.44	0.82				0.12	900.0
	1	1						222						

BH0003  B: RT  Test Maryann Einarson  Type Class # ID  OHC 1 7 1C  OHC 1 7 1C  OHC 2 20 2C  OHC 2 20 2C  OHC 2 20 2C  OHC 3 33 3D  OHC 3 33 3D  OHC 3 33 3D  OHC 3 4 46 4C	Volume (%) 57.5 1 57.5 57.5 57.5	Comparison of Laminated Comp. to Braided Textiles for Boeing Helicopters           Average Dimensions (in)         Load at ness         Ultimate Dimensions (in)         Load at hole         Load at hole         Load (kips)         (kips)         (ksi)           1.497         0.2503         0.1875         22.40         22.501         60.079         Fail           1.496         0.2510         0.1875         22.40         22.501         60.079         Fail           1.499         0.25494         0.1875         22.70         22.766         60.907         Fail           1.499         0.2494         0.1875         22.70         22.766         60.907         Fail           1.499         0.2494         0.1875         22.70         22.766         60.907         Fail	Laminated Comp. to B	b. to Braided Text  opters  odified IITRI)  Ultimate Gross Ult.  Load (kips) (ksi)  22.501 (60.079)  23.142 (61.647)  22.766 (60.907)  22.766 (60.907)  22.80 (60.88)  0.32 0.78	extiles  Ult. Failure Location/ ss Comments  7) Failure through hole @ 45 ang 07 Failure through hole @ 45 ang 08 Failure through hole @ 45 ang
Maryann Einarson Pierre Minguet St. Mat. Cell Panel CC 1 7 1C C 1 7 1C C 2 20 2C C 2 20 2C C 2 20 2C C 3 33 3D C 3 33 3D C 3 33 3D C 4 46 4C	Fiber Volume (%) 57.5 57.5	Dimensions (in) Thick Hole ness Dia 1 2503 0.1875 0.2510 0.1875 0.2494 0.1875 Average	lesuits (Mo Load at U Audible (kips) 22.40 21.40 22.70 22.70	diffied IITRI)           Utimate Load         Gross Street           (kips)         (ks)           22.501         60.0           22.766         60.6           22.80         60.9           22.80         60.0	
Maryann Einarson Pierre Minguet st Mat. Cell Panel C 1 7 1C C 1 7 1C C 2 20 2C C 2 20 2C C 2 20 2C C 3 33 3D C 3 33 3D C 3 33 3D C 4 46 4C	1 Fiber Volume (%) 57.5 57.5	Dimensions (in) Thick Hole ness Dia 1 2503 0.1875 0.2510 0.1875 0.2494 0.1875 Average	Load at L Audible ( <i>kips</i> ) 22.40 22.70 22.70 22.17	diffied IITRI)           Load         Street           Load         Street           (kips)         (ks           22.501         60.0           23.142         61.6           22.766         60.3           22.80         60.3           0.32         0.32	<u> </u>
Pierre Minguet  Pierre Minguet  C	Fiber Volume   (%)   57.5   57.5	Dimensions (in) Thick Hole ness Dia 1 2503 0.1875 25494 0.1875 Average	Load at L Audible (kips) 22.40 22.70 22.70 22.17	Load Stre (kips) (ks 22.501 60.0 22.766 60.0 22.80 60.0	<u> </u>
Test Mat. Cell Panel Type Class # D OHC 1 7 1C OHC 1 7 1C OHC 2 20 2C OHC 2 20 2C OHC 2 20 2C OHC 3 33 3D OHC 3 33 3D OHC 3 33 3D OHC 3 33 3D OHC 4 46 4C	Fiber Volume (%) 57.5 57.5 57.5	Dimensions (in) Thick Hole ness Dia 1 2503 0.1875 0.2510 0.1875 0.2494 0.1875 Average		<del>                                     </del>	<u> </u>
Type         Class         #         ID           OHC         1         7         1C           OHC         1         7         1C           OHC         1         7         1C           OHC         2         20         2C           OHC         2         20         2C           OHC         2         20         2C           OHC         3         33         3D           OHC         3         33         3D           OHC         3         33         3D           OHC         4         46         4C	Volume (%) 57.5 57.5 57.5	Thick Hole ness Dia 1 0.2503 0.1875 0.2510 0.1875 0.2494 0.1875 Average			
OFC         OFC         1         7         1         1         7         1 <td>(%) 57.5 1.497 57.5 1.496 57.5 1.499</td> <td></td> <td></td> <td></td> <td><del></del></td>	(%) 57.5 1.497 57.5 1.496 57.5 1.499				<del></del>
OHC         1         7         1C           OHC         1         7         1C           OHC         2         20         2C           OHC         2         20         2C           OHC         3         33         3D           OHC         3         33         3D           OHC         3         33         3D           OHC         3         33         3D           OHC         4         46         46           OHC         4         46         46	57.5 1.497 57.5 1.496 57.5 1.499				
OHC         1         7         1C           OHC         1         7         1C           OHC         2         20         2C           OHC         2         20         2C           OHC         3         33         3D           OHC         3         33         3D           OHC         3         33         3D           OHC         3         33         3D           OHC         4         46         47	57.5 1.496 57.5 1.499	<del></del>		<u> </u>	
OHC         1         7         1C           OHC         2         20         2C           OHC         2         20         2C           OHC         3         33         3D           OHC         4         46         47	57.5 1.499			<u> </u>	
OHC 2 20 2C OHC 3 33 3D OHC 3 33 3D OHC 3 33 3D OHC 3 48 46 4C		Average	22.17		<b>88</b> 8 0
OHC 2 20 2C OHC 3 33 3D OHC 3 33 3D OHC 3 33 3D OHC 3 48 46 4C				<del></del>	<b></b>
OCC 2 20 2C C C C C C C C C C C C C C C C		Std. Dev.		_	<u> </u>
O+C		% COV		1.41 1.29	6
OHC     2     20       OHC     2     20       OHC     3     33       OHC     3     33       OHC     3     33       OHC     3     33       OHC     3     34       OHC	57.9 1.498	0.2495 0.1875	26.00	26.360 70.558	
OHC 2 20 2C COHC 3 33 3D OHC 3 33 3D OHC 4 4 6 6 7 6 7 6 7 6 7 6 7 6 7 6 7 6 7 6	57.9 1.498	0.2501 0.1870	25.50	25.989 69.372	
OHC 3 33 3D OHC 3 33 3D OHC 4 4 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	57.9 1.499	0.2482 0.1870	none	27.040 72.681	81 Failure through hole
OHC 3 33 3D OHC 3 33 3D OHC 4 4 8 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	⊢	Average	25.75	26.46 70.87	18
O+C 3 33 3D O+C 3 33 3D O+C 4 48 48 46 4C		Std. Dev.	<u> </u>	0.53 1.68	89
O+C 3 33 3D O+C 3 33 3D O+C 3 3 3 3D O+C 3 3 3 3 5D O+C 3 3 3 3 5D O+C 3 5D		% COV		2.01 2.37	
O+C 3 33 3D O+C 3 33 3D O+C 4 46 8 5 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	59.6 1.498	0.2481 0.1895	_		
OHC 3 33 3D OHC 4 46 4C	59.6 1.500	0.2479 0.1885	15.30	15.587 41.937	_
OHC 4 46 4C	59.6 1.496	0.2468 0.1885	15.40	15.488 41.952	52 Failure through hole
O+C 4 46 4C		Average	15.43	15.67 42.25	25
OHC 4 46 4C		Std. Dev.		0.23 0.53	
OHC 4 46 4C		% COV		1.46 1.24	14
	58.3 1.499	0.2996 0.1890	29.60	29.932 66.638	
4 46 4C	58.3 1.499	0.2971 0.1895	27.70	29.614   66.514	_
OFC 4	58.3 1.498	0.2986 0.1895	28.00	28.822 64.428	28 Failure through hole
↓_		Average	28.43	29.46 65.86	98
		Std. Dev.		0.57 1.24	4:
		% COV		1.94 1.8	68.

intec												
Project #: BH0003	: BH0003	_				Comp	arison (	of Lamina for Boe	Laminated Comp. to B for Boeing Helicopters	Comparison of Laminated Comp. to Braided Textiles for Boeing Helicopters	ided Text	iles
Temperature:	;; ;;	H							0			
intec Engineer:	3er:	Maryann Einarson	ın Eina	ırson		Open H	ole Trans	verse Co	mpressio	Open Hole Transverse Compression Results (Modified IITRI)	(Modified	IITRI)
Boeing engineer:	ineer:	Pierre Minguet	Mingue	¥								
Specimen	Test	Mat.	Sel	Panel	Fiber	Average	Average Dimensions (in)	ions (in)	Load at	Ultimate	Gross Ult.	Failure Location/
₽	Туре	Class	#		Volume	Width	Thick	Hole	Audible	Load	Stress	Comments
					8		ness	Dia 1	(kips)	(kips)	(ksi)	
BH3-130		-	80	ပ္	57.5	1.499	0.2482	0.1895	13.02	13.664	36.730	Failure through hole
BH3-131		-	ω	<u>ဂ</u>	57.5	1.498	0.2465	0.1870	15.30	15.893	43.061	Failure through hole
BH3-132	유다.	-	æ	5	57.5	1.499	0.2499	0.1870	14.90	15.173	40.513	Failure through hole
								Average	14.41	14.91	40.10	
								Std. Dev.		1.14	3.19	
								% COV		7.63	7.94	
BH3-142		N	21	႙	57.9	1.500	0.2475	0.1870	19.80	21.378	57.603	Failure through hole
BH3-143		8	21	၃	57.9	1.498	0.2525	0.1870	20.80	21.841	57.746	Failure through hole
BH3-144	OHC-T	2	21	SC	57.9	1.497	0.2486	0.1870	20.80	21.866	58.738	Failure through hole
								Average	20.47	21.70	58.03	
					•			Std. Dev.		0.27	0.62	
								% COV		1.27	1.07	
BH3-195		ო	34	3D	59.6	1.500	0.2447	0.1885	none	15.807	43.069	Failure through hole
BH3-196		ო	34	<u>а</u> е	59.6	1.499	0.2453	0.1885	попе	15.868	43.174	Failure through hole
BH3-197	유민	9	34	as Ge	59.6	1.499	0.2387	0.1890	none	15.750	44.038	Failure through hole
								Average		15.81	43.43	
								Std. Dev.		90.0	0.53	
								% COV		0.37	1.23	
BH3-166		4	47	<b>4</b>	58.3	1.498	0.2985	0.1895	23.60	25.971	58.087	Failure through hole
BH3-167		4	47	5	58.3	1.498	0.2959	0.1895	24.40	24.754	55.867	Failure through hole
BH3-168	OHC-T	4	47	40	58.3	1.496	0.2990	0.1890	23.00	24.916	55.700	Failure through hole
					-			Average	23.67	25.21	56.55	
								Std. Dev.		99.0	1.33	
			1	1				000 %		2.62	2.36	

intec Project #: BH0003	8				Co	nparison	of Lamina	aminated Composite	osites to E	Comparison of Laminated Composites to Braided Textiles	iles			
Temperature: intec engineer: Boeing engineer:		RT Maryann Einar Pierre Minguet	RT Maryann Einarson Pierre Minguet	5			Rail	Rail Shear Results	ults				Chord	
Specimen Te	Tast	Mat	Panel	Fiber	Average D	de Dimensions	Load at	Ultimate	Ultimate	Ultimate	Ultimate	Ultimate	Ax. SG	Failure
		_	۵		Width	Thick	Audible	Load	Stress	+45° Strn	-45° Strn	90° Strn	Modulus	mode
				(%)	-	ness	(kips)	(kips)	(ksi)	(те)	(με)	(3π)	(MPSI)	
BH3-082 F	82	-	18	6.99	3.005	0.1057	11.14	11.510	36.232	5950	-6530	672	3.05	bearing
	·Ω	-	18	6.99	3.023	0.1063	12.18	12.340	38.419	5973	-6998	923	3.00	bearing
	· £	-	<u>4</u>	6.99	3.015	0.1051	13.20	13.305	42.008	6494	-6966	750	3.22	bearing
┺						Average	12.17	12.38	38.89	6139	-6831	782	3.09	
						Std. Dev.		06.0	2.92				0.12	
						% COV		7.25	7.50				3.73	
BH3-094 F	RS	2	28	66.0	3.013	0.1076	12.66	12.770	39.396	12275	-13322	-302	1.80	shear
	RS	~	2B	66.0	3.004	0.1086	12.18	12.236	37.502	11854	-12363	-12	1.77	shear
	. S	۱ ۵	5B	66.0	3.002	0.1083		13.434	41.321	13412	-14739	-354	1.99	shear
<u> </u>						Average	12.42	12.81	39.41	12514	-13475	-223	1.85	
						Std. Dev.		09.0	1.91				0.12	
		,				% COV		4.68	4.85				6.44	
BH3-106 F	  g	3	38	66.2	3.012	0.1113	13.30	13.916	41.537	5050	-5408	٦a	4.37	bearing
	82	· e	38	66.2	3.014	0.1114	11.40	12.900	38.438	4239	-4726	1548	4.53	bearing
		· e	38	66.2	3.003	0.1103	12.50	13.748	41.500	4379	-4960	па	4.67	bearing
丄	-					Average	12.40	13.52	40.49	4556	-5031	1548	4.52	
						Std. Dev.		0.54	1.78				0.15	
						% COV		4.03	4.39				3.32	
RH3-118	lφ	4	4B	66.4	2.996	0.1250	11.70	12.632	33.749	7219	-7708	324	2.33	bearing
	 ! 82	4	4B	66.4	2.985	0.1285	13.80	13.868	36.159	1960	-8303	84	2.39	bearing
	 ! 82	4	48	66.4	3.006	0.1247	11.40	13.306	35.497	7729	-8165	744	2.39	bearing
						Average	12.30	13.27	35.14	7636	-8059	384	2.37	
						Std. Dev.		0.62	1.24				0.03	
						% COV		4.66	3.54				1.46	

Figure Congruent   Figure   Mary and   Fiber   Fib	Temperature: intec engineer:	İ				₽	r Boeing Helicopters	Helicopte	ırs						
	Boeing enginee		T aryann erre M	ו Einarsc linguet	E	Ō	ouble Sh	ear Beari	ng Result	ø					
	-		lat. Pa		ber		verage [	imension	S	Load at	Failur	3 Load	Bearing	1 Stress	Failure Mode/
		Ded C			L		Thick	용 :		Audible	Limit	j į	Limit	ļ.	
		+	+	1	(%)	$\dagger$	Ness	Ula 1	DIST 1	(KIPS)	(kips)	(KIPS)	(KSI)	(KSI)	
		- BS	<del>-</del>			.503	0.1066	0.2505	0.6285	3.90	3.668	4.361	137.59	163.59	Shear out
		<u>8</u>	· -				0.1078	0.2505	0.6295	3.65	3.667	4.079	136.07	151.35	Shear out
		딠			+	-	0.1090	0.2505	0.6265	3.35	4.008	4.372	147.04	160.39	Shear out
									Average	3.63	3.781	4.271	140.23	158.44	
	-								Std. Dev.	0.28	0.20	0.17	5.94	6.35	
									\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	7.58	5.20	3.89	4.24	4.00	
	1	┖	╁	├	$\vdash$	╁	0.1081	0.2510	0.6200	3.65	3.362	4.612	124.40	170.66	Shear out
							0.1077	0.2515	0.6245	3.90	3.955	4.470	146.93	166.07	Shear out
			$\dashv$	긕		$\dashv$	0.1065	0.2510	0.6260	3.80	3.874	4.628	145.46	173.77	Shear out
									Average	3.78	3.730	4.570	138.93	170.16	
									Std. Dev.	0.13	0.32	60.0	12.60	3.87	
						_	<u> </u>		\ 000 %	3.33	8.62	1.90	6.07	2.28	
		丄	+	+	+	+-	0.1134	0.2510	0.6300	3.30	3.912	4.661	137.95	164.36	Bearing
		_					0.1134	0.2510	0.6295	3.20	3.825	4.567	134.88	161.05	Bearing
					_	_	0.1125	0.2510	0.6295	3.15	3.487	4.234	124.02	150.59	Bearing
						_			Average	3.22	3.741	4.487	132.28	158.66	
				_					Std. Dev.	0.08	0.22	0.22	7.32	7.19	
									> % %	2.37	9.00	2.00	5.53	4.53	
	_		-				0.1288	0.2510	0.6280	4.30	4.427	5.719	137.45	177.56	Bearing
							0.1288	0.2510	0.6295	4.30	4.667	5.647	144.98	175.42	Bearing
			$\dashv$	4	$\dashv$		0.1269	0.2510	0.6310	3.55	4.299	5.258	135.54	165.78	Bearing
							-		Average	4.05	4.464	5.541	139.32	172.92	
_		-							Std. Dev.	0.43	0.19	0.25	4.99	6.28	
	_	$\dashv$	$\dashv$	$\dashv$	-	$\dashv$			\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	10.69	4.18	4.48	3.58	3.63	
The contraction of the contracti		aring s	tress c	alculater	d from: L	oad/ac	tual thickr	18SS/nomi 2: Firet en	hal hole dia ecimen Hi	ameter ilok side	Hole 3. Sec	and energing	Hilok eid	2 · V olo II	sociate reactions broad
	-	- Te 01 +i	to bue	roce ron	recent 2	alod %	diameter	officet or 1	and of firet	zero elone	whichever	ii bearinge	,		

Project #: BH0003   Comparison of Laminated Single Shear Bearing Results   Comparison of Laminatory   Comparison	Parameter   Para	Inrec																
Part	Particular   Par	Project #: B	1500E	e		-	Compari	son of L fo	r Boeing	Composi Helicopte	tes to Br rs	raided Tex	tiles					
State   Mail Panel Fiber   Mai	Plant   Plan	Temperature:	_	띪						•								
Mat. Parale Fiber	Mat. Panel Fiber	intec engineer		Maryanr	L Einar	Son	Stabiliz	ignis be	e Shear B	earing R	esuits							
Test   Mat   Pare   Floar   Floar   Continuation   Load of Lailure   Load of Lailu	Type   Class   Divided   Thick   Hole   Ho	Boeing engine		Pierre M	linguel													
Type         Class         D         Vol.         Width         Thick         Hole         Edge         Edge         Audible         Limit         Ulft         Ulft         Ulft         Ulft         Ulft         Ulft         Limit         Limit         Limit         Limit         Limit	Type Class D Vol. Width Thick Hole Hole Edge Edge Audible Umit Ult Unit Ultimate SSSS 1 1 14 66.3 15.0 1 0.1069 0.2510 0.5510 0.6510 0.6500 6.25 6.855 6.917 107.53 17.03 17.03 18.55 11.0069 0.2510 0.5510 0.6510 0.6510 0.6500 0.6510 0.6500 0.6510 0.6510 0.6500 0.6510 0.6500 0.6510 0.6510 0.6500 0.6510 0.6510 0.6500 0.6510	-	_	Mat. Pa		iber			Verage D	imension	S		Load at	Failure	Load	Bearing	Stress	Failure Mode/
SSSB   1   14   663   1.501   0.1690   0.2551   0.6310   0.6300   6.25   5.855   6.917   10.053   127.03     SSSB   1   14   663   1.501   0.1089   0.2510   0.2551   0.6310   0.6310   6.35   6.176   6.989   113.64   137.05     SSSB   1   14   663   1.501   0.1089   0.2510   0.2505   0.6310   0.6310   6.35   6.176   6.989   113.64   127.93     SSSB   1   14   663   1.501   0.1072   0.2505   0.2510   0.6310   0.6310   0.6310   0.6310   0.7611   0.765   0.7611   0.765   0.7611   0.765   0.7611   0.765   0.7611	SSSB         1         (%)         ness         Dia 1         Dia 2         Dia 1         Dia 2         (Rip 2)         <			Class			Width		Hole	Hole		Edge	Audible	Limit	ັ້ລ	Limit	Ultimate	Comments
SSSB 1 14 66.3 1.501 0.1089 0.2510 0.2510 0.6310 0.6300 6.25 5.855 6.917 107.53 127.03 132.05 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	8558 1 14 663 1501 0.1069 0.2510 0.2510 0.6530 6.25 5.855 6.917 107.53 127.03					(%)		ness	Dia 1	Dia 2	Dist 1	Dist 2	(kips)	(kips)	(kips)	(ksi)	(ksi)	
SSSB 1 14 66.3 1.501 0.1064 0.2510 0.2505 0.6310 6.35 6.176 6.985 6.917 110.09 130.06  SSSB 1 14 66.3 1.502 0.1088 0.2510 0.2551 0.6310 6.35 6.176 6.989 113.56 113.56 113.59  SSSB 1 14 66.3 1.501 0.1093 0.2510 0.2510 0.6310 6.316 6.35 6.176 6.989 113.56 113.09  SSSB 1 14 66.3 1.501 0.1093 0.2510 0.2510 0.6310 0.6310 7.00 6.761 7.455 122.12 140.31  SSSB 1 14 66.3 1.501 0.1092 0.2510 0.2510 0.6310 7.00 6.761 7.455 122.12 140.31  SSSB 2 24 65.7 1.502 0.1068 0.2515 0.6250 0.6280 5.50 5.90 7.211 111.01 135.00  SSSB 2 24 65.7 1.502 0.1068 0.2510 0.6250 0.6280 5.50 5.90 7.211 111.01 135.00  SSSB 2 24 65.7 1.501 0.1066 0.2510 0.6250 0.6280 5.50 5.90 7.211 111.01 135.00  SSSB 2 24 65.7 1.501 0.1068 0.2050 0.2510 0.6280 5.00 5.00 7.211 111.28 135.33  SSSB 2 24 65.7 1.501 0.1068 0.2050 0.2510 0.6290 5.00 5.00 7.211 111.28 135.33  SSSB 2 34 65.7 1.502 0.1072 0.2060 0.2510 0.6290 5.00 5.00 7.211 111.28 135.33  SSSB 3 34 65.8 1.503 0.116 0.2505 0.2510 0.6290 5.00 7.295 118.92 137.86  SSSB 3 34 65.8 1.503 0.116 0.2505 0.2510 0.6290 6.293 7.295 118.92 137.86  SSSB 3 34 65.8 1.503 0.116 0.2505 0.2510 0.6200 6.300 7.311 11.51 11.647 128.85  SSSB 3 34 65.8 1.503 0.116 0.2505 0.2510 0.6200 6.300 7.311 11.61 11.60 129.91  SSSB 3 34 65.8 1.503 0.116 0.2505 0.2510 0.6306 0.6310 4.10 6.500 7.191 11.647 128.85  SSSB 3 34 65.8 1.503 0.116 0.2505 0.2510 0.6306 0.6310 4.10 6.500 7.191 11.647 128.85  SSSB 3 34 65.8 1.503 0.116 0.2505 0.2510 0.6306 0.6310 6.306 0.5310 1.10 6.309 1.3040  SSSB 3 34 65.8 1.503 0.116 0.2505 0.2510 0.6306 0.6310 6.306 0.5307 7.313 111.15 129.40  SSSB 3 34 65.8 1.503 0.116 0.2510 0.2505 0.6310 6.306 0.5310 1.006 0.307 7.311 11.10 0.944  SSSB 3 34 65.8 1.503 0.116 0.2510 0.2505 0.6310 6.306 0.6310 6.306 0.309 1.3040 0.309 1.3040 0.309 1.3040 0.309 0.3000 0.300	SSSB 1 1A 66.3 1501 0.1064 0.2501 0.2505 0.6310 6.635 6.176 6.999 113.04 113.05 130.08	BH3-010 S	SSB	-	├	66.3	⊢	0.1089	0.2510	0.2510	0.6310	0.6300	6.25	5.855	6.917	107.53	127.03	Bearing hole 1&4
SSSB 1 14 66.3 1.502 0.1088 0.2510 0.5510 0.6310 6.35 6.176 6.989 113.56 122.93  SSSB 1 14 66.3 1.501 0.1093 0.2510 0.2550 0.6310 0.6315 7.00 6.761 7.455 126.14 139.09  SSSB 1 14 66.3 1.501 0.1092 0.2510 0.0510 0.6310 7.00 6.761 7.455 126.14 139.09  SSSB 2 24 65.7 1.502 0.1088 0.2515 0.2510 0.6220 5.50 5.50 5.50 0.46 0.29 10.10 7.27  SSSB 2 24 65.7 1.501 0.1098 0.2515 0.2510 0.6220 5.50 5.50 5.90 7.21 111.01 135.00  SSSB 2 24 65.7 1.502 0.1068 0.2515 0.2510 0.6220 5.50 5.90 7.21 111.01 135.00  SSSB 2 24 65.7 1.502 0.1068 0.2515 0.2510 0.6220 5.50 5.90 7.211 111.01 135.00  SSSB 2 34 65.7 1.502 0.1072 0.2500 0.2510 0.6220 5.00 5.00 5.10 5.10 5.10 1.00 1.00 0.2510 0.2510 0.6220 5.00 5.00 5.00 5.00 5.10 5.10 1.00 0.2510 0.2510 0.6220 0.6220 5.00 5.10 5.10 5.10 1.00 0.2510 0.2510 0.6220 0.6220 5.00 5.00 5.10 5.10 1.00 0.2510 0.2510 0.6220 0.6220 5.00 5.10 5.10 5.10 1.00 0.2510 0.2510 0.6220 0.6220 5.00 5.10 5.10 5.10 1.00 0.2510 0.2510 0.6220 0.6220 5.00 5.10 5.10 5.10 1.00 0.2510 0.2510 0.6220 0.6220 5.10 5.10 5.10 5.10 1.00 0.2510 0.2510 0.6220 0.6220 5.10 5.10 5.10 1.00 0.2510 0.2510 0.6220 0.6220 5.10 5.10 5.10 1.00 0.2510 0.2510 0.6220 0.6220 5.10 5.10 5.10 5.10 1.00 0.2510 0.2510 0.6220 0.6220 5.10 5.10 5.10 5.10 1.00 0.2510 0.6220 0.6220 5.10 5.10 5.10 5.10 5.10 5.10 0.2510 0.6220 0.6220 5.10 5.10 5.10 5.10 5.10 5.10 5.10 5.1	SSSB 1 1A 66.3 1.501 0.1072 0.2510 0.2510 0.6310 0.6315 7.00 6.761 7.455 113.56 113.56 113.04 127.93   SSSB 1 1A 66.3 1.501 0.1072 0.2505 0.6310 0.6310 0.6315 7.00 6.761 7.455 126.14 193.99   SSSB 1 1A 66.3 1.501 0.1072 0.2505 0.2510 0.6310 0.6315 7.00 6.761 7.455 126.14 193.99   SSSB 1 1A 66.3 1.501 0.1072 0.2505 0.2510 0.6270 0.6300 7.00 6.761 7.455 126.14 193.99   SSSB 2 2A 65.7 1.502 0.1066 0.2510 0.2515 0.6250 0.6250 5.50 5.50 7.211 111.01 135.00   SSSB 2 2A 65.7 1.502 0.1066 0.2510 0.2515 0.6250 0.6250 5.50 5.50 7.211 111.01 135.00   SSSB 2 2A 65.7 1.501 0.1079 0.2510 0.2515 0.6250 5.50 5.50 7.211 111.28 135.39   SSSB 2 2A 65.7 1.502 0.1066 0.2510 0.2515 0.6250 5.50 5.50 5.503 7.211 111.01 135.00   SSSB 2 2A 65.7 1.502 0.1066 0.2510 0.2515 0.6250 5.50 5.50 5.50 7.211 111.01 135.00   SSSB 2 3A 65.8 1.504 0.1103 0.2510 0.6250 0.6250 5.50 5.50 7.297 108.54 136.59   SSSB 3 3A 65.8 1.504 0.1103 0.2510 0.2510 0.6230 0.6370 6.10 6.293 7.297 108.54 136.59   SSSB 3 3A 65.8 1.503 0.1106 0.2510 0.2510 0.6305 0.6310 0.6300 0.6340 0.558   SSSB 3 3A 65.8 1.503 0.1106 0.2510 0.2510 0.6305 0.6310 0.6390 0.53	BH3-011 S	SSB	_		66.3		0.1064	0.2510	0.2505	0.6310	0.6310	6.25	5.855	6.917	110.09	130.06	
SSSB 1 14 663 1501 0.1093 0.2510 0.2505 0.6310 0.6335 6.176 6.999 113.04 127.25 140.31 SSSB 1 144 663 1.501 0.1072 0.2505 0.2501 0.6301 7.00 6.761 7.455 1127.25 140.31 130.94 130.99   SSSB 2 24 65.7 1.502 0.1066 0.2515 0.2510 0.6200 0.6200 5.50 5.930 7.271 111.01 135.00 5.51   SSSB 2 24 65.7 1.502 0.1066 0.2515 0.2510 0.6200 0.6205 5.50 5.930 7.211 111.01 135.00   SSSB 2 24 65.7 1.502 0.1066 0.2515 0.2510 0.6200 0.6200 5.50 5.930 7.211 111.01 135.00   SSSB 2 24 65.7 1.502 0.1066 0.2510 0.2510 0.6200 0.6200 5.50 5.930 7.211 111.01 135.00   SSSB 2 24 65.7 1.502 0.1066 0.2510 0.2510 0.6200 0.6200 5.10 5.10 5.10 1.384 96.80 138.49   SSSB 2 24 65.7 1.502 0.1068 0.2500 0.2510 0.6200 0.6200 5.10 5.10 5.10 1.384 96.80 138.49   SSSB 3 34 65.8 1.504 0.1103 0.2510 0.6200 0.6200 6.620 5.10 5.10 5.10 1.384 96.80 138.49   SSSB 3 34 65.8 1.504 0.1103 0.2510 0.6200 0.6210 6.203 0.6200 7.191 11.01 136.10   SSSB 3 34 65.8 1.504 0.1103 0.2510 0.6200 0.6310 6.6300 7.191 11.01 11.01 136.10   SSSB 3 34 65.8 1.503 0.1116 0.2500 0.2510 0.6200 0.6310 6.500 7.191 11.04 130.37   SSSB 3 34 65.8 1.503 0.1116 0.2500 0.2510 0.6300 0.6310 6.500 7.191 11.06 1.088 1.07   SSSB 3 34 65.8 1.503 0.1109 0.2510 0.6200 0.6310 6.500 7.191 11.00 1.089 1.07   SSSB 3 34 65.8 1.503 0.1109 0.2510 0.6200 0.6310 6.500 7.191 11.00 1.00 1.00 1.00 1.00 1.00 1.00	SSSB 1 1A 66.3 1.501 0.1030 0.2510 0.2505 0.6310 0.6310 0.6310 0.6310 1.0310 1.1304 1.12793 SSSB 1 1A 66.3 1.501 0.1062 0.2510 0.2510 0.6310 0.6315 7.00 6.761 7.455 1.27.25 1.127.29 SSSB 1 1A 66.3 1.501 0.1072 0.2505 0.2510 0.6300 7.00 6.701 7.455 1.12.10 11.1315 SSSB 2 2A 65.7 1.502 0.1068 0.2515 0.2510 0.6260 5.50 5.50 5.90 7.211 111.101 135.00 SSSB 2 2A 65.7 1.502 0.1066 0.2510 0.2515 0.6260 5.50 5.90 7.211 111.101 135.00 SSSB 2 2A 65.7 1.501 0.1079 0.2515 0.2510 0.6260 5.50 5.90 7.211 111.101 135.00 SSSB 2 2A 65.7 1.502 0.1066 0.2515 0.2510 0.6260 5.50 5.90 7.211 111.101 135.00 SSSB 2 2A 65.7 1.502 0.1066 0.2515 0.2510 0.6260 5.50 5.90 7.211 111.101 135.00 SSSB 2 2A 65.7 1.502 0.1066 0.2515 0.6210 0.6200 0.6200 5.90 7.211 111.101 135.00 SSSB 2 2A 65.7 1.502 0.1066 0.2515 0.6210 0.6200 0.6200 5.90 7.211 111.101 135.00 SSSB 3 3A 65.8 1.504 0.1030 0.2515 0.2510 0.6200 0.6200 0.6200 7.291 111.10 135.00 SSSB 3 3A 65.8 1.504 0.1103 0.2510 0.6200 0.6315 0.6300 7.191 11.647 136.10 SSSB 3 3A 65.8 1.503 0.1103 0.2510 0.2510 0.6305 0.6310 4.30 5.537 7.478 99.85 SSSB 3 3A 65.8 1.503 0.1103 0.2510 0.2510 0.6305 0.6310 6.500 7.191 11.647 136.10 SSSB 3 3A 65.8 1.503 0.1103 0.2510 0.2510 0.6305 0.6310 6.505 7.337 1.19 11.647 130.37 SSSB 3 3A 65.8 1.503 0.1103 0.2510 0.2510 0.6305 0.6310 6.500 7.191 11.647 130.37 SSSB 3 3A 65.8 1.503 0.1103 0.2510 0.2510 0.6305 0.6310 6.500 7.191 11.647 130.37 SSSB 3 3A 65.8 1.503 0.1103 0.2510 0.2510 0.6305 0.6310 6.305 0.6310 6.305 0.6310 6.305 0.6310 6.305 0.6310 6.305 0.6310 6.305 0.3010 0.30	BH3-012 S	SSB	-		66.3		0.1088	0.2510	0.2510	0.6320	0.6310	6.35	6.176	6.983	113.56	128.51	Bearing hole 1&4
1   1A   66.3   1.501   0.1063   0.2510   0.6310   0.6315   7.00   6.761   7.455   1.26.14   139.09   1.00   1.00   0.2565   0.2560   0.270   0.6270   0.700   6.53   6.264   7.120   1.16.11   131.95   1.20.14   131.95   1.20.14   131.95   1.20.14   1.20.	1 1A 66.3 1501 0.1063 0.2510 0.6210 0.6315 7.00 6.761 7.455 122.15 140319 1 1A 66.3 1.501 0.1072 0.2505 0.2510 0.6270 0.6300 7.00 6.761 7.455 122.14 139.09 2 2A 65.7 1.502 0.1066 0.2510 0.2510 0.6250 0.6260 5.50 5.900 7.211 111.28 136.39 2 2A 65.7 1.501 0.1066 0.2510 0.2510 0.6250 0.6200 5.50 5.900 7.211 111.28 136.39 2 2A 65.7 1.501 0.1066 0.2510 0.2510 0.6250 0.6200 5.50 5.900 7.211 111.28 136.39 2 2A 65.7 1.501 0.1066 0.2510 0.2510 0.6200 0.6200 5.50 5.900 7.211 111.28 136.39 2 2A 65.7 1.501 0.1066 0.2510 0.2510 0.6200 0.6200 5.50 5.900 7.211 111.28 136.39 2 2A 65.7 1.501 0.1066 0.2500 0.2510 0.6200 0.6200 5.50 5.900 7.211 111.28 136.39 2 2A 65.7 1.501 0.1066 0.2500 0.2510 0.6200 0.6200 5.900 7.211 111.28 136.39 2 2A 65.7 1.501 0.1066 0.2500 0.2510 0.6200 0.6200 5.900 7.211 111.28 136.39 2 2A 65.7 1.501 0.1066 0.2500 0.2510 0.6200 0.6200 5.900 7.211 111.28 136.39 2 3A 65.8 1.501 0.1069 0.2510 0.6200 0.6270 6.10 6.293 7.295 118.92 137.86 3 3A 65.8 1.502 0.1072 0.2505 0.2510 0.6200 0.6270 6.10 6.203 7.295 118.02 137.81 3 3A 65.8 1.503 0.116 0.2505 0.2510 0.6305 0.6310 4.10 6.500 7.191 116.47 128.85 3 3A 65.8 1.503 0.116 0.2505 0.2510 0.6305 0.6310 4.10 6.500 7.191 116.47 128.85 3 3A 65.8 1.503 0.116 0.2505 0.2510 0.6305 0.6315 6.300 7.191 116.47 128.85 3 3A 65.8 1.503 0.116 0.2505 0.2510 0.6305 0.6315 6.300 6.202 7.313 111.15 1190.44 3 3A 65.8 1.503 0.116 0.2505 0.2510 0.6305 0.6315 6.500 7.191 116.47 128.85 3 3A 65.8 1.503 0.116 0.2505 0.2510 0.6305 0.6315 6.060 7.191 116.47 128.85 3 3A 65.8 1.503 0.116 0.2510 0.2515 0.6305 0.6315 6.000 7.191 116.47 116.094 3 3A 65.8 1.503 0.116 0.2510 0.2515 0.6305 0.6315 6.000 7.191 116.47 116.094 3 3A 65.8 1.503 0.116 0.2510 0.2515 0.6305 0.6315 6.000 7.191 116.47 116.99 130.67 3 3A 65.8 1.503 0.116 0.2510 0.2515 0.6315 0.6306 0.301 0.014 110.41 10.41 0.044 3 3A 65.8 1.503 0.116 0.2510 0.2515 0.6315 0.6306 0.301 0.014 110.41 10.41 0.044 3 3A 65.8 1.503 0.116 0.2510 0.2510 0.6306 0.6315 0.6006 0.301 0.014 0.014 110.41 0.044 3 5A 65.8 1.503 0.116 0.2510 0.2510 0.6306 0.6315	BH3-013 S	SSB	-	_	66.3		0.1093	0.2510	0.2505	0.6310	0.6310	6.35	6.176	686.9	113.04	127.93	,
SSSB         1         66.3         1.501         0.1072         0.2510         0.6270         6.761         7.455         126.14         139.09           SSSB         2         1.501         0.1072         0.2510         0.6270         6.6264         7.130         4.10         8.70         5.51           SSSB         2         2A         65.7         1.502         0.1068         0.2515         0.6250         5.50         5.930         7.211         111.128         135.33           SSSB         2         2A         65.7         1.502         0.1068         0.2516         0.6250         5.50         5.930         7.211         111.128         135.33           SSSB         2         A         65.7         1.502         0.1068         0.2516         0.6230         5.50         5.930         7.211         111.101         135.30           SSSB         2         A         65.7         1.502         0.1066         0.2506         0.6230         5.00         5.161         7.384         96.89         136.91           SSSB         2         A         65.7         1.502         0.1072         0.2506         0.6240         0.6256         5.10         5.161 <td>SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6260 5.50 5.930 7.201 111.011 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.10 5.10 7.384 95.69 138.91 95.53 95.85</td> <td>BH3-014 S</td> <td>SSB</td> <td>-</td> <td></td> <td>66.3</td> <td></td> <td>0.1063</td> <td>0.2510</td> <td>0.2510</td> <td>0.6310</td> <td>0.6315</td> <td>7.8</td> <td>6.761</td> <td>7.455</td> <td>127.25</td> <td>140.31</td> <td>Bearing holes 1&amp;4</td>	SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6260 5.50 5.930 7.201 111.011 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6250 0.6250 5.10 5.10 7.384 95.69 138.91 95.53 95.85	BH3-014 S	SSB	-		66.3		0.1063	0.2510	0.2510	0.6310	0.6315	7.8	6.761	7.455	127.25	140.31	Bearing holes 1&4
SSSB         2         2A         65.7         1.502         0.106         0.2515         0.2510         0.6250         6.550         5.930         7.211         111.01         131.95           SSSB         2         2A         65.7         1.502         0.1068         0.2515         0.6250         0.6250         5.930         7.211         111.01         135.00           SSSB         2         2A         65.7         1.501         0.1066         0.2510         0.6250         6.50         5.930         7.211         111.01         135.00           SSSB         2         2A         65.7         1.502         0.1066         0.2510         0.6250         6.50         5.930         7.211         111.01         135.00           SSSB         2         A         65.7         1.502         0.1066         0.2510         0.6250         6.293         7.294         96.69         136.10           SSSB         2         A         65.7         1.502         0.1072         0.250         0.6250         6.293         7.295         11.91         136.10           SSSB         2         A         65.7         1.502         0.1072         0.250         0.6250	SSSB 2	BH3-015 S	SSB	-		66.3		0.1072	0.2505	0.2510	0.6270	0.6300	7.00	6.761	7.455	126.14	139.09	
SSSB         2         2A         65.7         1.502         0.106         0.251         0.6250         6.560         5.930         7.211         111.01         135.00           SSSB         2         2A         65.7         1.501         0.1066         0.2510         0.2550         0.6260         5.50         5.930         7.211         111.01         135.00           SSSB         2         2A         65.7         1.501         0.1079         0.2510         0.6240         0.6210         5.161         7.384         95.69         136.31           SSSB         2         2A         65.7         1.501         0.1079         0.2510         0.6220         6.6270         5.161         7.384         95.69         136.91           SSSB         2         2A         65.7         1.502         0.1072         0.2510         0.6220         6.0270         5.161         7.384         95.69         136.91           SSSB         2         A         65.7         1.502         0.1072         0.2510         0.2510         0.6220         6.020         5.161         7.384         95.69         136.91           SSSB         2         A         65.7         1.502	SSSB 2 2A 65.7 1.502 0.1068 0.2515 0.2510 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2500 0.6250 0.6250 5.50 5.930 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2505 0.2510 0.6250 6.10 5.10 5.10 7.394 95.69 138.91 SSSB 2 2A 65.7 1.502 0.1066 0.2505 0.2510 0.6250 6.10 5.10 5.10 1.7394 95.69 138.91 SSSB 2 2A 65.7 1.502 0.1066 0.2505 0.2510 0.6250 6.10 6.293 7.295 118.92 137.86 SSSB 2 2A 65.7 1.502 0.1066 0.2505 0.2510 0.6250 6.10 6.293 7.295 118.92 137.89 SSSB 2 2A 65.7 1.502 0.1072 0.2505 0.2510 0.6250 6.10 6.293 7.295 118.92 137.89 SSSB 3 3A 65.8 1.503 0.110 0.2510 0.2510 0.6250 0.6310 4.10 6.500 7.191 11.647 136.10 SSSB 3 3A 65.8 1.503 0.110 0.2510 0.2510 0.6305 0.6310 4.30 6.507 7.478 99.85 134.86 SSSB 3 3A 65.8 1.503 0.110 0.2510 0.2510 0.6305 0.6310 4.30 6.537 7.478 99.85 134.86 SSSB 3 3A 65.8 1.503 0.110 0.2510 0.2510 0.6305 0.6310 4.30 6.537 7.478 99.85 134.86 SSSB 3 3A 65.8 1.503 0.110 0.2510 0.2510 0.6305 0.6315 5.00 6.202 7.391 11.16 47 10.89 SSSB 3 3A 65.8 1.503 0.110 0.2510 0.2510 0.6305 0.6310 4.30 6.537 7.478 99.85 134.86 SSSB 3 3A 65.8 1.503 0.110 0.2510 0.2510 0.6305 0.6315 5.00 6.532 7.313 111.15 11.15											Average	6.53	6.264	7.120	116.11	131.95	
SSSB         2         2A         65.7         1.502         0.1068         0.2516         0.6250         5.50         5.930         7.211         111.01         135.00           SSSB         2         2A         65.7         1.502         0.1068         0.2516         0.6250         5.50         5.930         7.211         111.01         135.00           SSSB         2         2A         65.7         1.501         0.1079         0.2510         0.6240         0.6210         5.10         7.211         111.01         135.00           SSSB         2         2A         65.7         1.502         0.1066         0.2510         0.6236         5.50         5.101         7.384         95.69         136.91           SSSB         2         2A         65.7         1.502         0.1072         0.2510         0.6236         6.250         5.101         7.384         95.69         136.91           SSSB         2         2A         65.7         1.502         0.1072         0.2510         0.6236         6.10         6.106         6.293         7.294         116.91         136.99           SSSB         2         A         65.7         1.502         0.1026	SSSB         2         2A         65.7         1.502         0.1068         0.2515         0.2510         0.6260         5.50         5.930         7.211         111.01         135.00           SSSB         2         2A         65.7         1.501         0.1066         0.2510         0.6250         5.50         5.930         7.211         111.101         135.00           SSSB         2         2A         65.7         1.501         0.1066         0.2510         0.6250         5.50         5.930         7.211         111.101         135.00           SSSB         2         2A         65.7         1.501         0.1079         0.2510         0.6230         5.050         5.930         7.211         111.101         135.00           SSSB         2         2A         65.7         1.502         0.1072         0.2510         0.6230         6.293         7.294         9.680         138.49           SSSB         2         2A         65.7         1.502         0.1072         0.2500         0.6230         6.629         5.795         1.1741         136.10           SSSB         2         A         65.7         1.502         0.1072         0.2500         0.6230 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>•</td> <td></td> <td>Std. Dev.</td> <td>,</td> <td>0.46</td> <td>0.29</td> <td>10.10</td> <td>7.27</td> <td></td>									•		Std. Dev.	,	0.46	0.29	10.10	7.27	
SSSB         2         2A         65.7         1.502         0.1068         0.2510         0.6250         6.590         7.211         111.01         135.00           SSSB         2         2A         65.7         1.501         0.1066         0.2510         0.2515         0.6235         6.6260         5.90         7.211         111.28         135.30           SSSB         2         2A         65.7         1.501         0.1066         0.2510         0.6240         0.6210         5.161         7.384         95.69         136.91           SSSB         2         2A         65.7         1.501         0.1066         0.2510         0.6220         5.10         5.161         7.384         95.69         136.91           SSSB         2         2A         65.7         1.502         0.1066         0.2510         0.6220         6.10         5.161         7.384         95.69         136.91           SSSB         2         A         65.7         1.502         0.1072         0.2510         0.6250         6.10         5.161         7.384         96.80         136.91           SSSB         3         A         65.7         1.502         0.1072         0.2510	SSSB 2 2A 65.7 1.502 0.1066 0.2516 0.6256 0.6256 5.50 5.90 7.211 111.01 135.00 SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.2515 0.6235 0.6256 5.50 5.90 7.211 111.28 135.33 SSSB 2 2A 65.7 1.501 0.1079 0.2510 0.2510 0.6240 0.6250 5.10 5.161 7.384 95.69 136.91 SSSB 2 2A 65.7 1.501 0.1079 0.2510 0.6240 0.6250 6.10 6.293 7.295 118.92 137.86 SSSB 2 2A 65.7 1.502 0.1072 0.2505 0.2510 0.6250 6.6270 6.10 6.293 7.295 118.92 137.86 SSSB 3 3A 65.8 1.504 0.1103 0.2510 0.2510 0.6250 0.6310 6.203 7.295 11.81 11.81 136.10 SSSB 3 3A 65.8 1.503 0.1116 0.2505 0.2510 0.6305 0.6310 4.10 6.500 7.191 11.784 130.37 SSSB 3 3A 65.8 1.503 0.1116 0.2505 0.2510 0.6305 0.6310 4.30 6.500 7.191 11.784 130.37 SSSB 3 3A 65.8 1.503 0.1116 0.2505 0.2510 0.6305 0.6310 6.500 7.191 11.784 130.37 SSSB 3 3A 65.8 1.503 0.1116 0.2505 0.2510 0.6305 0.6310 6.500 7.191 11.784 130.37 SSSB 3 3A 65.8 1.503 0.1116 0.2505 0.2510 0.6305 0.6310 6.500 7.191 11.116 0.2505 0.2510 0.2505 0.6315 0.6305 0.6315 0.6305 0.2510 0.2505 0.2510 0.2505 0.2510 0.2505 0.6315 0.6305 0.2510 0.2505 0.2510 0.2505 0.6315 0.6305 0.2510 0.2510 0.2505 0.2505 0.2505 0											\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \		7.33	4.10	8.70	5.51	
SSSB 2 2A 65.7 1.501 0.1066 0.2510 0.6240 0.6210 5.10 5.101 7.384 95.69 136.31 SSSB 2 2A 65.7 1.501 0.1079 0.2510 0.6240 0.6210 5.10 5.101 7.384 95.69 136.91 SSSB 2 2A 65.7 1.502 0.1066 0.2505 0.2510 0.6235 0.6250 5.10 5.161 7.384 95.69 138.49 SSSB 2 2A 65.7 1.502 0.1072 0.2505 0.2510 0.6230 0.6270 6.10 6.293 7.295 118.92 137.86 SSSB 2 2A 65.7 1.502 0.1072 0.2505 0.2510 0.6250 0.6270 6.10 6.293 7.295 118.92 137.86 SSSB 3 3A 65.8 1.504 0.1103 0.2510 0.2510 0.6305 0.6310 4.10 6.500 7.191 11.784 130.37 SSSB 3 3A 65.8 1.503 0.1116 0.2555 0.6315 0.6305 0.6316 4.10 6.500 7.191 11.784 130.37 SSSB 3 3A 65.8 1.503 0.1106 0.2510 0.2510 0.6305 0.6310 4.10 6.500 7.191 11.784 130.37 SSSB 3 3A 65.8 1.503 0.1106 0.2510 0.2510 0.6305 0.6310 4.10 6.500 7.191 11.784 130.37 SSSB 3 3A 65.8 1.503 0.1106 0.2510 0.2510 0.6305 0.6316 4.10 6.500 7.191 11.15 11.15 12.845 SSSB 3 3A 65.8 1.503 0.1106 0.2510 0.2510 0.6305 0.6316 7.304 7.305 7.478 99.85 134.86 SSSB 3 3A 65.8 1.503 0.1106 0.2510 0.2510 0.6305 0.6316 5.00 6.282 7.313 111.15 12.940 SSSB 3 3A 65.8 1.503 0.1136 0.2510 0.2510 0.6305 0.6316 5.00 6.282 7.313 111.15 12.940 SSSB 3 3A 65.8 1.503 0.1136 0.2510 0.2510 0.6305 0.6316 5.00 6.282 7.313 111.15 12.940 SSSB 3 3A 65.8 1.503 0.1136 0.2510 0.2515 0.6325 0.6315 5.00 6.282 7.313 111.15 12.940 SSSB 3 3A 65.8 1.503 0.1136 0.2510 0.2515 0.6325 0.6315 5.00 6.282 7.313 111.15 1.9940 SSSB 3 3A 65.8 1.503 0.1136 0.2510 0.2515 0.6325 0.6315 5.00 6.282 7.313 111.15 1.9940 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2515 0.6325 0.6315 5.00 6.282 7.313 111.15 1.9940 SSSB 3 3A 65.8 1.503 0.1136 0.2515 0.6325 0.6315 5.00 6.282 7.313 111.15 0.9940 SSSB 3 3A 65.8 1.503 0.1136 0.2515 0.6325 0.6315 5.00 6.282 7.313 111.15 0.9940 SSSB 3 3A 65.8 1.503 0.1136 0.2515 0.6325 0.6315 5.00 6.282 7.313 111.15 0.9940 SSSB 3 3A 65.8 1.503 0.1136 0.2515 0.6325 0.6315 5.00 6.282 7.313 111.15 0.9940 SSSB 3 3A 65.8 1.503 0.1136 0.2515 0.6325 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.6315 0.63	SSSB 2 24 65.7 1.501 0.1066 0.2516 0.6235 0.6250 5.50 5.930 7.211 111.28 135.33 SSSB 2 24 65.7 1.501 0.1066 0.2510 0.6230 0.6230 5.10 5.101 7.384 95.69 136.91 SSSB 2 24 65.7 1.502 0.1066 0.2500 0.2510 0.6235 0.6250 5.10 6.293 7.295 118.92 136.10 SSSB 2 24 65.7 1.502 0.1072 0.2505 0.2510 0.6230 6.10 6.293 7.295 118.92 137.86 SSSB 3 34 65.8 1.504 0.1073 0.2510 0.6230 0.6230 6.50 6.293 7.295 118.92 136.10 SSSB 3 34 65.8 1.504 0.1103 0.2510 0.6305 0.6310 4.10 6.500 7.191 117.84 130.37 SSSB 3 34 65.8 1.503 0.1116 0.2505 0.2510 0.6305 0.6310 4.10 6.500 7.191 116.47 128.85 SSSB 3 34 65.8 1.503 0.1109 0.2510 0.2510 0.6305 0.6310 4.10 6.500 7.191 116.47 128.85 SSSB 3 34 65.8 1.503 0.1109 0.2510 0.2510 0.6305 0.6310 6.200 7.191 116.47 128.85 SSSB 3 34 65.8 1.503 0.1109 0.2510 0.2510 0.6305 0.6310 6.200 7.191 116.47 11.116 0.2505 0.2510 0.2510 0.6305 0.6310 6.200 7.191 116.47 128.85 SSSB 3 34 65.8 1.503 0.1109 0.2510 0.2510 0.6305 0.6310 6.200 7.191 116.47 11.116 0.2901 0.2510 0.2510 0.6305 0.6310 6.200 7.191 116.47 0.94 SSSB 3 34 65.8 1.503 0.1109 0.2510 0.2510 0.6305 0.6310 6.200 7.191 116.0 0.04 0.2510 0.2	RH3-028	SSB	╁	+-	65.7	1 502	0.1068	0.2515	0.2510	0.6250	0.6260	5.50	5.930	7.211	111.01	135.00	Bearing holes 1&4
SSSB 2 24 65.7 1.501 0.1079 0.2510 0.6240 0.6250 5.10 5.161 7.384 95.69 136.91  SSSB 2 24 65.7 1.502 0.1066 0.2505 0.2510 0.6255 6.10 5.161 7.384 96.80 138.49  SSSB 2 24 65.7 1.502 0.1058 0.2500 0.2510 0.6255 6.10 6.293 7.295 118.92 137.86  SSSB 2 24 65.7 1.502 0.1072 0.2505 0.2510 0.6250 6.10 6.293 7.295 118.92 137.86  SSSB 3 34 65.8 1.504 0.1103 0.2510 0.2505 0.6315 0.6305 0.6315 5.00 6.282 7.313 111.60 129.40  SSSB 3 34 65.8 1.503 0.1106 0.2510 0.2505 0.6315 0.6306 0.6340 0.5315 5.00 6.282 7.313 111.60 129.40  SSSB 3 34 65.8 1.503 0.1106 0.2510 0.2505 0.6315 0.6340 0.5315 5.00 6.282 7.313 111.60 129.40  SSSB 3 34 65.8 1.503 0.1106 0.2510 0.2505 0.6315 0.6340 0.5315 5.00 6.282 7.313 111.60 129.40  SSSB 3 34 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.60 129.40  SSSB 3 34 65.8 1.503 0.1130 0.2510 0.2505 0.6315 0.6340 4.30 5.537 7.478 99.85 134.86  SSSB 3 34 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.60 129.40  SSSB 3 34 65.8 1.503 0.1130 0.2510 0.2505 0.6315 0.6340 4.30 5.537 7.478 99.85 134.86  SSSB 3 34 65.8 1.503 0.1130 0.2510 0.2505 0.6315 0.6340 4.30 6.282 7.313 111.60 0.2594 0.094	SSSB         2         2A         65.7         1.501         0.1079         0.2510         0.2510         0.6240         0.6210         5.161         7.384         95.69         136.91           SSSB         2         2A         65.7         1.502         0.1066         0.2505         0.2510         0.6235         6.50         5.161         7.384         96.80         138.49           SSSB         2         2A         65.7         1.501         0.1056         0.2510         0.6230         6.203         7.295         117.41         136.10           SSSB         2         2A         65.7         1.502         0.1072         0.2510         0.6230         0.6270         6.10         6.293         7.295         117.41         136.10           SSSB         3         4         65.8         1.504         0.1103         0.2510         0.6230         0.6270         6.10         6.293         7.295         117.41         136.59           SSSB         3         A         65.8         1.504         0.1103         0.2510         0.2510         0.6230         0.6310         6.6303         7.19         1.174         136.59           SSSB         3         A	BH3-029	SSB			65.7	55	0.1066	0.2510	0.2515	0.6235	0.6250	5.50	5.930	7.211	111.28	135.33	
SSSB 2 2A 65.7 1.502 0.1066 0.2505 0.2510 0.6255 6.10 6.293 7.295 118.92 137.86 5.59	SSSB 2 2A 65.7 1.502 0.1066 0.2505 0.2510 0.6235 0.6250 5.10 5.161 7.384 96.80 138.49 SSSB 2. 2A 65.7 1.501 0.1058 0.2500 0.2510 0.6250 6.10 6.293 7.295 118.92 137.86 SSSB 2 2A 65.7 1.502 0.1072 0.2505 0.2510 0.6250 6.10 6.293 7.295 118.92 137.86 SSSB 3 3A 65.8 1.504 0.1103 0.2510 0.6305 0.6315 4.10 6.500 7.191 117.84 130.37 SSSB 3 3A 65.8 1.503 0.1116 0.2505 0.6315 0.6305 0.6315 5.00 6.292 7.313 111.6 129.91 SSSB 3 3A 65.8 1.503 0.1126 0.2510 0.6305 0.6315 5.00 6.292 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1126 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 0.2510 0.2505 0.6316 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 0.72 0.73 0.130 0.2510 0.2505 0.6316 0.6316 0.6316 0.034 0.	BH3-030 S	SSB			65.7	1.50	0.1079	0.2510	0.2510	0.6240	0.6210	5.10	5.161	7.384	95.69	136.91	Bearing holes 1&4
SSSB 2 2A 65.7 1.501 0.1058 0.2510 0.6250 0.6270 6.10 6.293 7.295 118.92 137.86   SSSB 2 2A 65.7 1.502 0.1072 0.2555 0.2510 0.6250 0.6270 6.10 6.293 7.295 117.41 136.10   SSSB 3 3A 65.8 1.504 0.1103 0.2510 0.6305 0.6315 4.10 6.500 7.191 116.47 128.85   SSSB 3 3A 65.8 1.502 0.1136 0.2510 0.6305 0.6315 4.10 6.500 7.191 116.47 128.85   SSSB 3 3A 65.8 1.503 0.1126 0.2510 0.2510 0.6305 0.6315 5.00 6.282 7.313 111.60 129.91   SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315 0.6345 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 3A 65.8 1.503 0.1130 0.2515 0.6315	SSSB         2         2A         65.7         1.501         0.1058         0.2500         0.2510         0.6255         6.10         6.293         7.295         118.92         137.86           SSSB         2         2A         65.7         1.502         0.1072         0.2500         0.2510         0.6250         6.057         5.795         7.297         108.54         136.10           SSSB         3         65.8         1.504         0.1103         0.2510         0.6250         0.6315         4.10         6.500         7.191         11.81         1.46           SSSB         3         4         65.8         1.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         11.81         1.46           SSSB         3         A         65.8         1.504         0.1106         0.2510         0.6305         0.6316         4.10         6.500         7.191         11.647         128.86           SSSB         3         A         65.8         1.503         0.1136         0.2510         0.6326         0.6340         4.30         5.37         7.478         99.85         134.86           SSSB         3	BH3-031 S	SSB			65.7	1.502	0.1066	0.2505	0.2510	0.6235	0.6250	5.10	5.161	7.384	96.80	138.49	
SSSB 3 4 65.8 1.502 0.1072 0.2505 0.2510 0.6250 0.6270 6.10 6.293 7.297 117.41 136.10 136.10	SSSB         2         2A         65.7         1.502         0.1072         0.2505         0.2510         0.6250         6.6270         6.10         6.293         7.297         108.54         136.59           SSSB         3         4.504         0.1072         0.2505         0.2510         0.6250         0.6315         4.10         6.500         7.191         108.54         136.59           SSSB         3         4.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         117.84         130.37           SSSB         3         4.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         117.84         130.37           SSSB         3         4.504         0.1104         0.2510         0.2505         0.6315         4.10         6.500         7.191         116.47         128.85           SSSB         3         4.504         0.2510         0.2510         0.2510         0.2510         0.6305         0.6345         5.00         6.106         7.478         99.85         134.86           SSSB         3         4.50         1.503         0.1136         0.2510	BH3-032 S	SSB			65.7		0.1058	0.2500	0.2510	0.6240	0.6255	6.10	6.293	7.295	118.92	137.86	Bearing holes 1&4
SSSB         3         65.8         1.504         0.1103         0.2510         0.2510         0.6305         0.6305         0.6305         0.6315         4.10         6.500         7.191         11.81         1.46           SSSB         3         4.58         1.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         117.84         130.37           SSSB         3         4.58         1.502         0.1116         0.2505         0.6305         0.6316         4.10         6.500         7.191         117.84         130.37           SSSB         3         4.58         1.502         0.1136         0.2510         0.6305         0.6340         4.30         5.537         7.478         97.52         131.71           SSSB         3         4.58         1.503         0.1126         0.2510         0.2515         0.6345         5.00         6.282         7.313         111.65         129.40           SSSB         3         4.58         1.503         0.1126         0.2510         0.2515         0.6345         5.00         6.282         7.313         111.15         129.40           SSSB         3         4.50	SSSB         3         65.8         1.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.19         108.54         136.59           SSSB         3         46.58         1.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         11.784         130.37           SSSB         3         46.58         1.502         0.1106         0.2510         0.6305         0.6316         4.10         6.500         7.191         117.84         130.37           SSSB         3         46.58         1.502         0.1106         0.2510         0.6305         0.6316         4.10         6.500         7.191         116.47         128.85           SSSB         3         46.58         1.502         0.1136         0.2510         0.6326         0.6340         4.30         5.537         7.478         99.85         134.86           SSSB         3         46.58         1.503         0.1130         0.2510         0.6326         0.6340         4.30         5.537         7.478         99.85         134.86           SSSB         3         46.58         1.503         0.1130         0.2510 </td <td>BH3-033 S</td> <td>SSB</td> <td></td> <td>-</td> <td>65.7</td> <td></td> <td>0.1072</td> <td>0.2505</td> <td>0.2510</td> <td>0.6250</td> <td>0.6270</td> <td>6.10</td> <td>6.293</td> <td>7.295</td> <td>117.41</td> <td>136.10</td> <td></td>	BH3-033 S	SSB		-	65.7		0.1072	0.2505	0.2510	0.6250	0.6270	6.10	6.293	7.295	117.41	136.10	
SSSB         3         4         65.8         1.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         11.784         130.37           SSSB         3         4         65.8         1.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         117.84         130.37           SSSB         3         4         65.8         1.503         0.1116         0.2505         0.6315         0.6306         4.10         6.500         7.191         116.47         128.85           SSSB         3         4         65.8         1.503         0.1136         0.2510         0.6326         0.6340         4.30         5.537         7.478         97.52         131.71           SSSB         3         4         65.8         1.503         0.1126         0.2510         0.6326         0.6345         5.00         6.282         7.378         99.85         139.40           SSSB         3         4         65.8         1.503         0.1130         0.2510         0.2515         0.6326         0.6345         5.00         6.282         7.313         111.15         11.94 <tr< td=""><td>SSSB 3 3A 65.8 1.504 0.1103 0.2510 0.6305 0.6315 4.10 6.500 7.191 117.84 130.37 SSSB 3 3A 65.8 1.502 0.1136 0.2510 0.6305 0.6310 4.10 6.500 7.191 117.84 130.37 SSSB 3 3A 65.8 1.502 0.1136 0.2510 0.6305 0.6310 4.30 6.537 7.478 97.52 131.71 SSSB 3 3A 65.8 1.503 0.1126 0.2510 0.6320 0.6340 4.30 6.587 7.478 99.85 134.86 SSSB 3 3A 65.8 1.503 0.1126 0.2510 0.6320 0.6315 5.00 6.282 7.313 111.60 129.91 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.60 129.91 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6320 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6320 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6320 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6360 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6360 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6360 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6360 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6360 0.6315 5.00 6.282 7.313 111.15 1.240 0.94 SSCOND SPECIMEN Hole 1. First specimen, fastener head side. Hole 2. First specimen, Hilok side. Hole 3. Second specimen, Hilok side. Hole 3. Second specimen, Hilok side. Hole 2. First specimen, Hilok side. Hole 3. Second specimen, Hilok side. Hole 4. Second specimen</td><td></td><td></td><td>╁╴</td><td>╁</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Average</td><td>5.57</td><td>5.795</td><td>7.297</td><td>108.54</td><td>136.59</td><td></td></tr<>	SSSB 3 3A 65.8 1.504 0.1103 0.2510 0.6305 0.6315 4.10 6.500 7.191 117.84 130.37 SSSB 3 3A 65.8 1.502 0.1136 0.2510 0.6305 0.6310 4.10 6.500 7.191 117.84 130.37 SSSB 3 3A 65.8 1.502 0.1136 0.2510 0.6305 0.6310 4.30 6.537 7.478 97.52 131.71 SSSB 3 3A 65.8 1.503 0.1126 0.2510 0.6320 0.6340 4.30 6.587 7.478 99.85 134.86 SSSB 3 3A 65.8 1.503 0.1126 0.2510 0.6320 0.6315 5.00 6.282 7.313 111.60 129.91 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.60 129.91 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6320 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6320 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6320 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6360 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6360 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6360 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6360 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 1.6360 0.6315 5.00 6.282 7.313 111.15 1.240 0.94 SSCOND SPECIMEN Hole 1. First specimen, fastener head side. Hole 2. First specimen, Hilok side. Hole 3. Second specimen, Hilok side. Hole 3. Second specimen, Hilok side. Hole 2. First specimen, Hilok side. Hole 3. Second specimen, Hilok side. Hole 4. Second specimen			╁╴	╁							Average	5.57	5.795	7.297	108.54	136.59	
SSSB         3         65.8         1.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         117.84         130.37           SSSB         3         4         65.8         1.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         117.84         130.37           SSSB         3         4         65.8         1.502         0.1136         0.2510         0.6305         0.6340         4.30         5.537         7.478         97.52         131.71           SSSB         3         3A         65.8         1.503         0.1136         0.2510         0.6320         0.6340         4.30         5.537         7.478         97.52         131.71           SSSB         3         A         65.8         1.503         0.1126         0.2510         0.6320         0.6345         5.00         6.282         7.313         111.6         129.40           SSSB         3         A         65.8         1.503         0.1130         0.2510         0.2515         0.6325         0.6326         7.313         111.15         129.40           SSSB         3         A	SSSB 3 A 65.8 1.504 0.1103 0.2510 0.6305 0.6315 4.10 6.500 7.191 117.84 130.37 SSSB 3 A 65.8 1.502 0.1116 0.2505 0.2510 0.6305 0.6310 4.10 6.500 7.191 116.47 128.85 SSSB 3 A 65.8 1.502 0.1136 0.2510 0.6305 0.6310 4.30 5.537 7.478 99.85 131.71 SSSB 3 A 65.8 1.503 0.1126 0.2510 0.6320 0.6340 4.30 5.537 7.478 99.85 134.86 SSSB 3 A 65.8 1.503 0.1126 0.2510 0.2515 0.6315 0.6345 5.00 6.282 7.313 111.60 129.91 SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 0.6315 0.0315 0.0315 0.0315 0.0315 0.04 6.282 7.313 111.15 129.40 SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6315 0.0315 0.04 6.282 7.313 111.15 129.40 SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 0.0315 0.0515 0.0											Std. Dev.		0.58	60.0	11.81	1.46	
SSSB         3         65.8         1.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         117.84         130.37           SSSB         3         A         65.8         1.503         0.1116         0.2505         0.2510         0.6305         0.6315         4.10         6.500         7.191         117.84         130.37           SSSB         3         A         65.8         1.502         0.1136         0.2510         0.6320         0.6340         4.30         5.537         7.478         97.52         131.71           SSSB         3         A         65.8         1.503         0.1109         0.2510         0.6320         0.6345         5.00         6.282         7.313         111.60         129.40           SSSB         3         A         65.8         1.503         0.1130         0.2515         0.6325         0.6345         5.00         6.282         7.313         111.15         129.40           SSSB         3         A         65.8         1.503         0.1130         0.2515         0.6325         0.6315         5.00         6.282         7.313         111.15         129.40           SSS	SSSB         3         65.8         1.504         0.1103         0.2510         0.6305         0.6315         4.10         6.500         7.191         117.84         130.37           SSSB         3         4         65.8         1.503         0.1116         0.2505         0.2510         0.6305         0.6315         4.10         6.500         7.191         117.84         130.37           SSSB         3         65.8         1.502         0.1136         0.2510         0.6305         0.6340         4.30         5.537         7.478         97.52         131.71           SSSB         3         65.8         1.503         0.1126         0.2510         0.6320         0.6345         5.00         6.282         7.313         111.60         129.91           SSSB         3         65.8         1.503         0.1136         0.2510         0.2515         0.6315         5.00         6.282         7.313         111.15         129.40           SSSB         3         65.8         1.503         0.1130         0.2510         0.2505         0.6315         5.00         6.282         7.313         111.15         129.40           SSSB         3         65.8         1.503								_			\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	7	9.97	1.19	10.88	1.07	
SSSB         3         65.8         1.503         0.1116         0.2505         0.6305         0.6310         4.10         6.500         7.191         116.47         128.85           SSSB         3         65.8         1.502         0.1136         0.2505         0.6315         0.6300         4.30         5.537         7.478         97.52         131.71           SSSB         3         65.8         1.503         0.1109         0.2510         0.2515         0.6345         5.00         6.282         7.478         99.85         134.86           SSSB         3         A         65.8         1.503         0.1126         0.2515         0.6315         0.6345         5.00         6.282         7.313         111.65         129.40           SSSB         3         A         65.8         1.503         0.1130         0.2515         0.6315         5.00         6.282         7.313         111.15         129.40           SSSB         3         A         65.8         1.503         0.130         0.2510         0.2555         0.6320         0.6315         5.00         6.282         7.313         111.15         129.40           A         A         A         A	SSSB 3 3A 65.8 1.503 0.1116 0.2505 0.6310 0.6305 0.6310 4.10 6.500 7.191 116.47 128.85 1.505 0.1116 0.2505 0.6315 0.6300 4.30 5.537 7.478 97.52 131.71 82.85 8 3.84 65.8 1.502 0.1136 0.2510 0.2510 0.6320 0.6340 4.30 5.537 7.478 99.85 134.86 82.85		ave	+	╬	85.8	+-	0 1103	0.2510	0.2510	0.6305	0.6315	4.10	6.500	7.191	117.84	130.37	Bearing holes 1&4
SSSB         3         65.8         1.502         0.1136         0.2510         0.2505         0.6320         0.6340         4.30         5.537         7.478         97.52         131.71           SSSB         3         4         65.8         1.503         0.1109         0.2510         0.6320         0.6346         4.30         5.537         7.478         99.85         134.86           SSSB         3         A         65.8         1.503         0.1126         0.2515         0.6315         5.00         6.282         7.313         111.60         129.91           SSSB         3         A         65.8         1.503         0.1130         0.2515         0.6326         0.6326         5.00         6.282         7.313         111.15         129.40           SSSB         3         A         65.8         1.503         0.1130         0.2516         0.6326         0.6326         7.317         111.15         129.40           A         A         A         A         6.106         7.327         108.99         130.67           A         A         A         A         A         A         A         A         A         A         A         A	SSSB 3 A 65.8 1.502 0.1136 0.2510 0.6320 0.6340 4.30 5.537 7.478 97.52 131.71   SSSB 3 A 65.8 1.503 0.1109 0.2510 0.6320 0.6340 4.30 5.537 7.478 99.85 134.86   SSSB 3 A 65.8 1.503 0.1126 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.60 129.91   SSSB 3 A 65.8 1.503 0.1130 0.2515 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2515 0.6320 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6320 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.15 129.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.15 1.29.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.15 1.29.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.15 1.29.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.15 1.29.40   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.15 0.94 7.304   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.6315 0.6315 0.6315 0.6315 0.6315 0.6317 0.14   SSSB 3 A 65.8 1.503 0.1130 0.2510 0.6315	BH2-047	0 00 00 00 00 00 00 00 00 00 00 00 00 00			65.8		0.1116	0.2505	0.2510	0.6305	0.6310	4.10	6.500	7.191	116.47	128.85	
SSSB         3         65.8         1.503         0.1109         0.2510         0.6320         0.6340         4.30         5.537         7.478         99.85         134.86           SSSB         3         34         65.8         1.503         0.1126         0.2515         0.6315         0.6345         5.00         6.282         7.313         111.60         129.91           SSSB         3         34         65.8         1.503         0.1130         0.2510         0.2505         0.6326         0.6315         5.00         6.282         7.313         111.15         129.40           SSSB         3         34         65.8         1.503         0.1130         0.2510         0.2505         0.6316         4.47         6.106         7.327         108.99         130.67           SIGL Dev.         51d. Dev.         0.51         0.14         10.41         0.94	SSSB 3 3A 65.8 1.503 0.1109 0.2510 0.6320 0.6340 4.30 5.537 7.478 99.85 134.86 SSSB 3 3A 65.8 1.503 0.1126 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.60 129.91 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2515 0.6315 5.00 6.282 7.313 111.15 129.40 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6315 5.00 6.282 7.313 111.15 129.40 Std. Dev.	BH3-048 S	d S			65.8	1.502	0.1136	0.2510	0.2505	0.6315	0.6300	4.30	5.537	7.478	97.52	131.71	Bearing holes 1&4
SSSB         3         65.8         1.503         0.1126         0.2510         0.2515         0.6315         0.6315         5.00         6.282         7.313         111.15         129.40           SSSB         3         3A         65.8         1.503         0.1130         0.2505         0.6320         0.6315         5.00         6.282         7.313         111.15         129.40           Average         4.47         6.106         7.327         108.99         130.67           Std. Dev.         Std. Dev.         0.51         0.14         10.41         0.94           % COV         8.27         1.97         9.55         0.72	SSSB 3 3A 65.8 1.503 0.1126 0.2510 0.2515 0.6320 0.6 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2505 0.6320 0.6 SSSB 3 3A 65.8 1.503 0.1130 0.2510 0.2510 0.2505 0.6320 0.6 SSSB 3 3A 65.8 1.503 0.1130 0.130 0	BH3-040 S	a d		_	65.8	1 503	0.1109	0.2510	0.2510	0.6320	0.6340	4.30	5.537	7.478	99.85	134.86	(Partial bearing hole 3)
SSSB         3         65.8         1.503         0.1130         0.2510         0.2505         0.6320         0.6315         5.00         6.282         7.313         111.15           Average         4.47         6.106         7.327         108.39           Sid         Dev.         0.51         0.14         10.41           % COV         8.27         1.97         9.55	SSSB   3   3A   65.8   1.503   0.1130   0.2510   0.2505   0.6320	BH3-050 S	8 6 8 6 8 6			65.8	1.503	0.1126	0.2510	0.2515	0.6315	0.6345	5.00	6.282	7.313	111.60	129.91	Bearing holes 1&4
Average     4.47     6.106     7.327     108.99       Std. Dev.     0.51     0.14     10.41       % COV     8.27     1.97     9.55	Bearing stress calculated from: Load/actual thickness/nominal hole diameter Hole 1: First specimen, fastener head side. Hole 2: First specimen, Hilok side.	BH3-051 S	SSB			65.8		0.1130	0.2510	0.2505	0.6320	0.6315	5.00	6.282	7.313	111.15	129.40	
0.51 0.14 10.41 8.27 1.97 9.55	Bearing stress calculated from: Load/actual thickness/nominal hole diameter Hole 1: First specimen, fastener head side. Hole 2: First specimen, Hilok side.			$\vdash$	╁╌							Average	4.47	6.106	7.327	108.99	130.67	
8.27 1.97 9.55	Bearing stress calculated from: Load/actual thickness/nominal hole diameter Hole 1: First specimen, fastener head side. Hole 2: First specimen, Hilok side.											Std. Dev.		0.51	0.14	10.41	0.94	
	Bearing stress calculated from: Load/actual thickness/nominal hole diameter Hole 1: First specimen, fastener head side. Hole 2: First specimen, Hilok side. Limit load and stress represent 2% hole diameter offset or load at first zero slop.											\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \		8.27	1.97	9.55	0.72	
			. <u>.</u>	יים ליני קיים ליני	1,000	ronroco	2% ho	emein el	tor offset	or load at	irst zero	slope, whi	chever occ	urred first.				

Project #: BH0003	Ŧ	6			Compa	Comparison of	Laminat	Laminated Composites to Braided Textiles	osites	to Braic	ded Tex	tiles					
							for Boein	for Boeing Helicopters	pters								
Temperature:	_	늄															
intec engineer:		Maryai	Maryann Einarson	arson	Stabl	Stabilized Sing	gle Shea	le Shear Bearing Results	g Resul	<b>\$</b>							
Boeing engineer:		Ріепе	Pierre Minguet	<b>#</b>			1	-	1								
Specimen   Test   Mat. Panel Fiber	est	Mat.	Panel	Fiber			Average	Average Dimensions	sions			Load at	Failur	Failure Load	Gircog	Booring Ottober	
<u>F</u>	ype	Type Class	D Vol.	Vol.	Width	Thick	유	훈	⊢	Edge	Food	Audible	<u>iæ</u> i	-	4	SCO DO	_
			_	8		ness	Dia 1				Dist 2	/kins	/kine	15 (a)	, CIMIL	Cumate	Comments
BH3-064 SSSB	SSB	4	44	64.3	1.503	0.1251	-	5 0 2510	╆	L	0 6330	8	603	103.0	(isu)	(ksi)	
BH3-065 SSSB	SSB	4	4	64.3	1.502	0.1275		_	_		06530	8 8	0.00	90.0	26.011	137.39	Bearing holes 1&4
BH3-066 SSSB	SSB	4	4	643	Ş	1201	_	_	_		3 6	8 6	0.850	g.594	108.82	134.79	
0000 200 000	0 0		•	5 5	3 5	_		_	_		0.6320	9	7.020	8.254	109.59	128.85	Bearing holes 1&4
\07-5EG	000	4	4	9 4 3	 		0.2515	0.2515	_	0.6300 0.	0.6310	6.50	7.020	8.254	114.28	134.36	
BH3-068 SSSB	SSB	4	<b>₹</b>	64.3	1.502	0.1258	0.2515	0.2515	_	0.6300   0.	0.6310	6.75	6.931	8 208	110 23	130.54	
BH3-069 SSSB	88	4	<b>4</b>	64.3	1.500	0.1276	0.2500	0.2515	_	0.6335 0.	0.6320	6.75	6.931	8 208	108.65	100.04	Dearing notes 164
	_		-					L	L	Ā	Average	6.72	6.963	8.352	110.25	132.26	
	_		_							S	Std. Dev.		0.05	0.21	99.0	4.52	
	$\dashv$	1							_	%	% COV		0.71	2.52	09'0	3.42	
Notes: Bearing stress calculated from: Load/actual thickness/nominal hole diameter	aring	stress	calcul	ated fro	om: Loak	d/actual ti	hickness/	nominal t	nole dian	meter							
웊	1:	First sp	pecime	in, faste	ner hea	d side.	tote 2: Fit	st specin	nen, Hik	ok side.	Hole 3:	Seconds	Decimen H	ilok side H	de 4. Secon	d enonimos	Hole 1: First specimen, fastener head side. Hole 2: First specimen, Hilok side. Hole 3: Second specimen, Hilok side. Hole 4: Second specimen, the side is the second specimen to the side.
ij	nit loa	d and	efrass	renres	ant 2% h	mein alor	oter offee	• or load	ot firet	ole ore	Iniday or	Limit load and stress represent 2% hole diameter offeet or load at first zone close which			1. COCCI		ı, idsiener nead side.
			3	5	2 110			282			₩		ITOO IIISI				

## Appendix B Typical Stress-Strain Curves

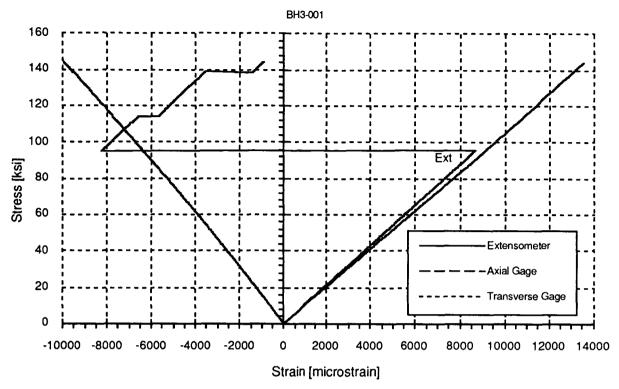


Figure B.1 Typical Longitudinal Tension Test Strain Data for Laminate L1.

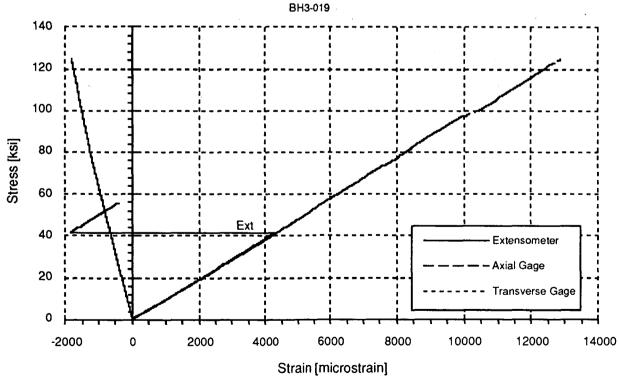


Figure B.2 Typical Longitudinal Tension Test Strain Data for Laminate L2.

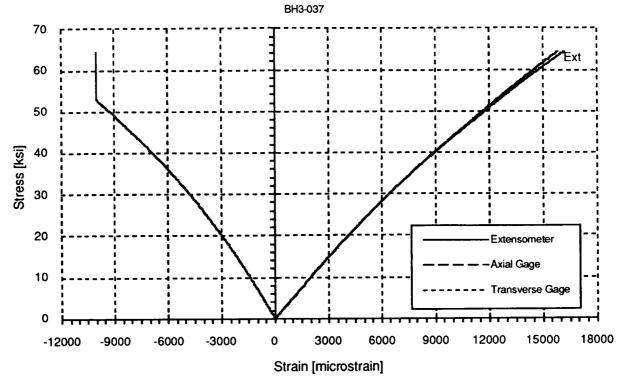


Figure B.3 Typical Longitudinal Tension Test Strain Data for Laminate L3.

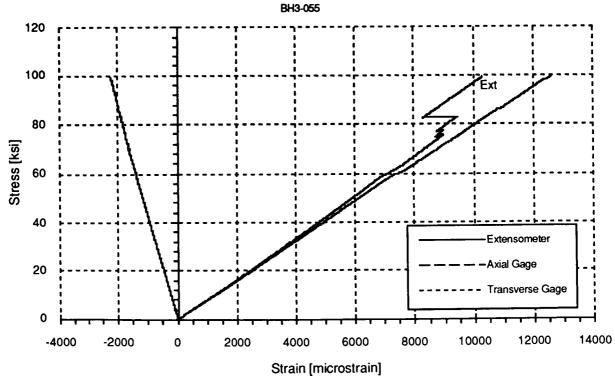


Figure B.4 Typical Longitudinal Tension Test Strain Data for Laminate L4.

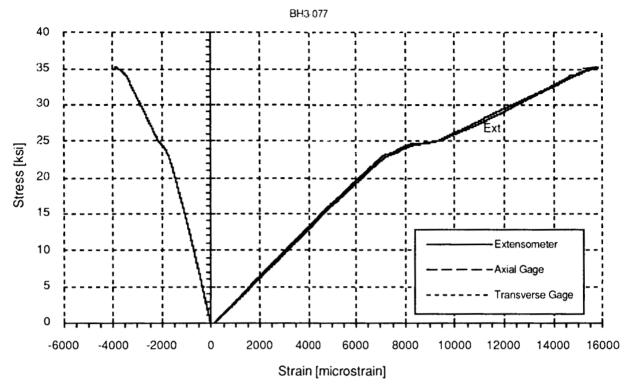


Figure B.5 Typical Transverse Tension Test Strain Data for Laminate L1.

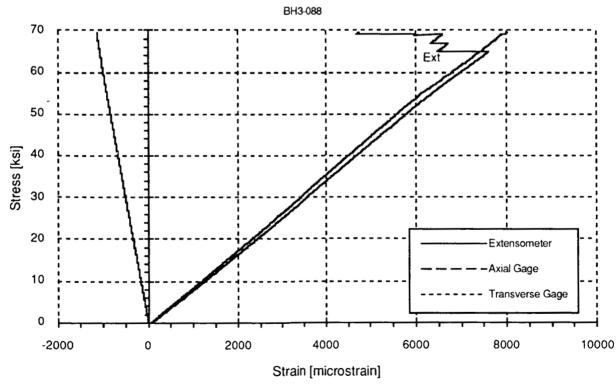


Figure B.6 Typical Transverse Tension Test Strain Data for Laminate L2.

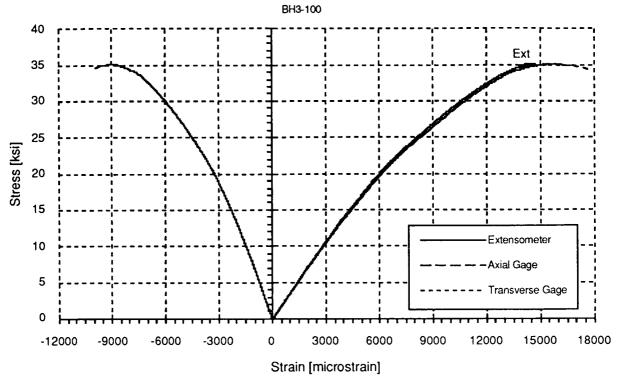


Figure B.7 Typical Transverse Tension Test Strain Data for Laminate L3.

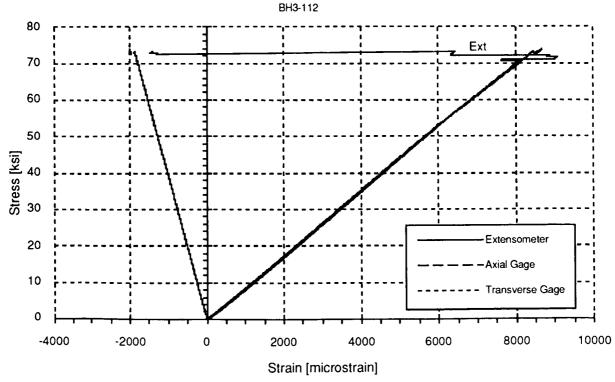


Figure B.8 Typical Transverse Tension Test Strain Data for Laminate L4.

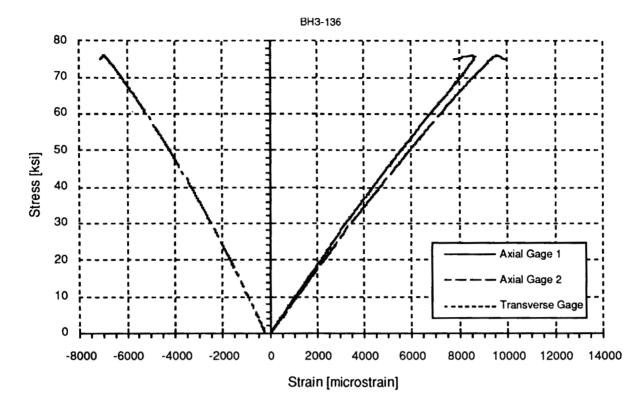


Figure B.9 Typical Longitudinal Compression Test Strain Data for Laminate L1.

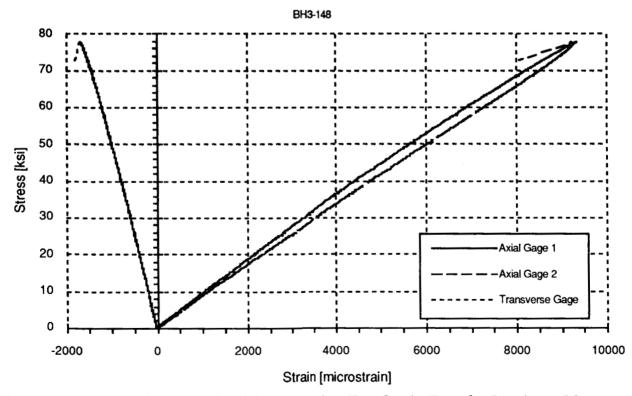


Figure B.10 Typical Longitudinal Compression Test Strain Data for Laminate L2.

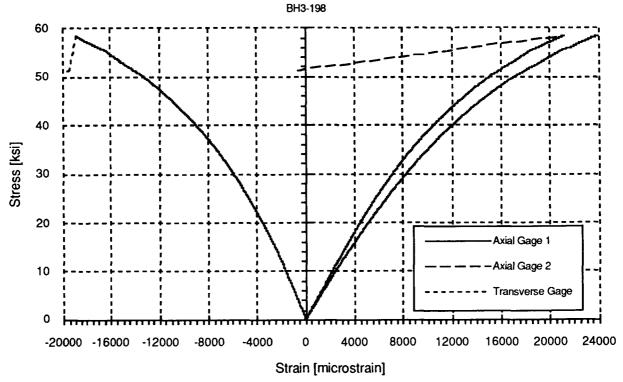


Figure B.11 Typical Longitudinal Compression Test Strain Data for Laminate L3.

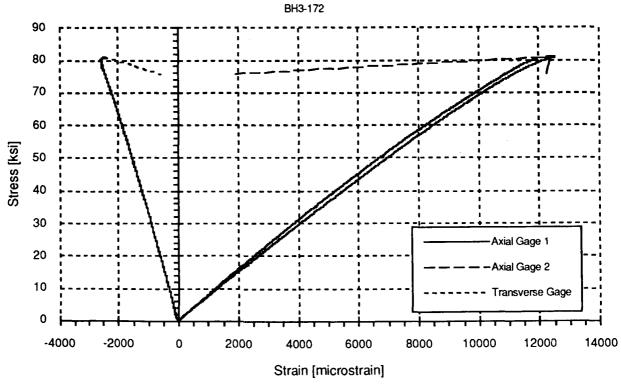


Figure B.12 Typical Longitudinal Compression Test Strain Data for Laminate L4.

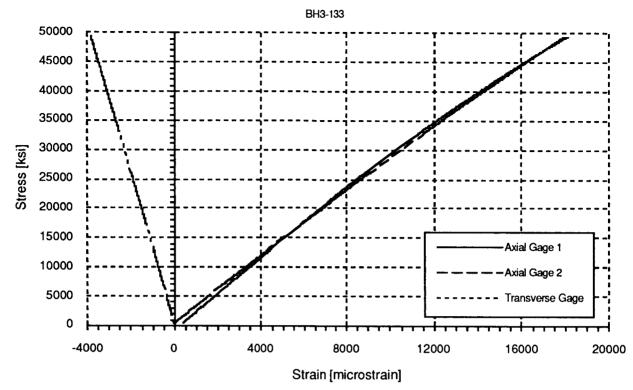


Figure B.13 Typical Transverse Compression Test Strain Data for Laminate L1.

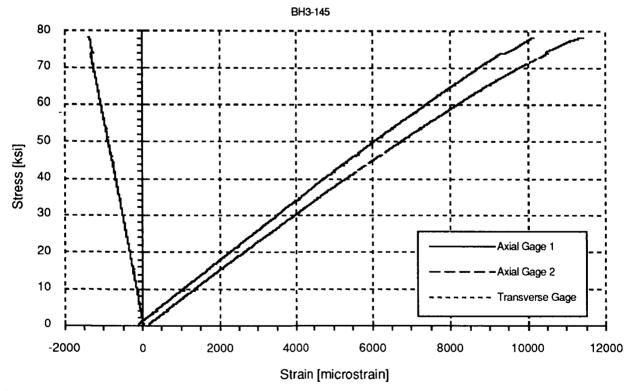


Figure B.14 Typical Transverse Compression Test Strain Data for Laminate L2.



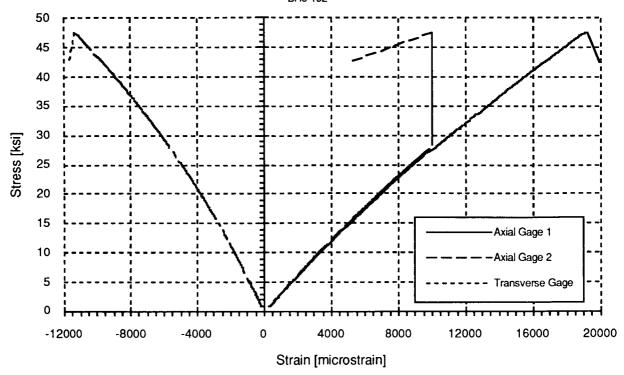


Figure B.15 Typical Transverse Compression Test Strain Data for Laminate L3.

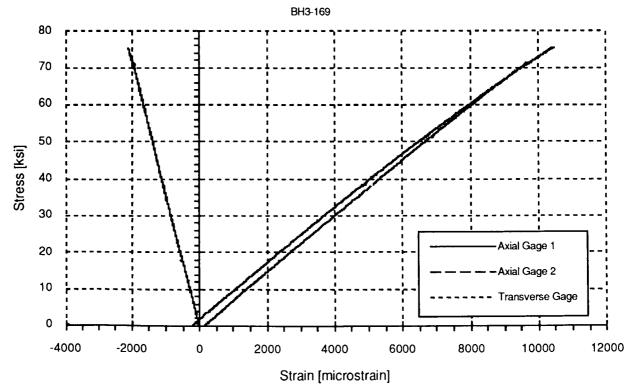


Figure B.16 Typical Transverse Compression Test Strain Data for Laminate L4.

## REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and

VA 22202-4302, and to the Office of Managemer	Washington Headquarters Services, Director it and Budget, Paperwork Reduction Project	rate for Information Operations and R (0704-0188), Washington, DC 2050	eports, 1215 Jefferson Davis Highway, Suite 1204, Arlington,
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYP	E AND DATES COVERED
	July 1994	Contractor F	
4. TITLE AND SUBTITLE			5. FUNDING NUMBERS
A Comparison of Graphite/Epo Composites Mechanical Prop		-D Braided	NAS1-19247
6. AUTHOR(S)			WU 510-02-12-09
Pierre J. Minguet and Christia	n K. Gunther		
7. PERFORMING ORGANIZATION NAME	(S) AND ADDRESS(ES)		8. PERFORMING ORGANIZATION
Boeing Defense & Space Gro Helicopters Division Philadelphia, PA 19142			REPORT NUMBER
9. SPONSORING / MONITORING AGENC	Y NAME(S) AND ADDRESS(ES)		10. SPONSORING / MONITORING
National Aeronautics and Spa	ce Administration		AGENCY REPORT NUMBER
Langley Research Center Hampton, VA 23681-0001			NASA CR-4610
11. SUPPLEMENTARY NOTES			<u> </u>
Langley Technical Monitor: C Final Report - Task 16			
12a. DISTRIBUTION / AVAILABILITY ST	ATEMENT		12b. DISTRIBUTION CODE
Unclassified-Unlimited			
Subject Category 26			
13. ABSTRACT (Maximum 200 words)			
A comparison of the in-plane 2-dimensional triaxially braide percentage of axial fibers and the laminates is AS4/3501-6 v This report documents the res	d composite was conducted the angle of the bias tows which was chosen as the coults of the testing of the laposite. The strength and tension, compression and	ed. The tape laminate in the braided compositosest available match aminates and compare stiffness properties mad open-hole compres	e layups were designed to match the osite. The material system used for h to AS4/1895 used for the braids, es these results with data previously neasured here include tension,
14. SUBJECT TERMS			15. NUMBER OF PAGES
Textile composites; Braiding;	Tension; Compression; S	hear; Bearing	56
			16. PRICE CODE A04
17. SECURITY CLASSIFICATION 18 OF REPORT Unclassified	SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFIC OF ABSTRACT	ATION 20. LIMITATION OF ABSTRACT